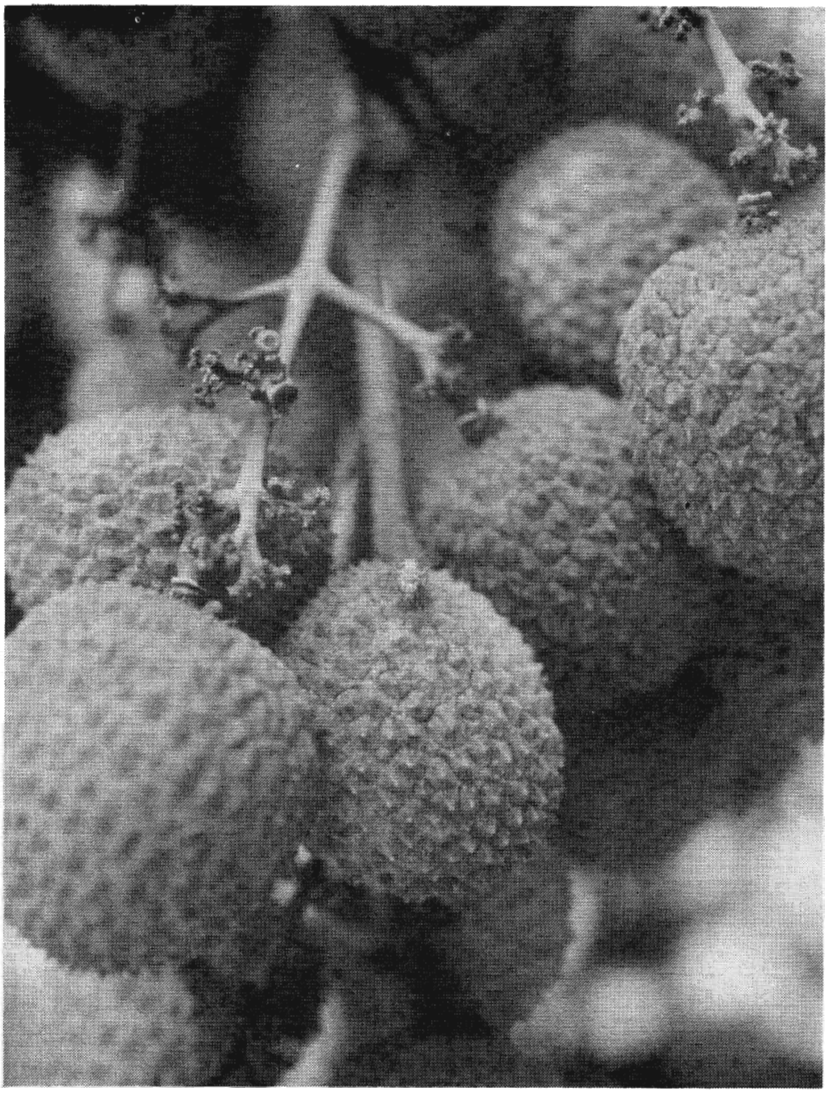
TAHR · COLLEGE OF TROPICAL AGRICULTURE AND HUMAN RESOURCES · UNIVERSITY OF HAWAII

PROCEEDINGS:

2nd ANNUAL HAWAII TROPICAL FRUIT GROWERS CONFERENCE

November 13 – 15, 1992
Hilo Hawaiian Hotel
Hilo, Hawaii



Proceedings:

Hawaii Tropical Fruit Growers Second Annual Conference

November 13 – 15, 1992
Hilo Hawaiian Hotel, Hilo, Hawaii

PREFACE

Tropical speciality fruits in Hawaii constitute a long list of crops. While many of these fruits are not uncommon in ethnic markets, selling to the mainstream consumer requires considerable effort and resources. Approved pest control methods and correct postharvest handling need to be implemented. Before any of the fruits can be exported fresh to the U.S. mainland, an effective postharvest disinfestation procedure for fruit flies needs to be developed. Several speakers addressed these issues.

Hurricane Iniki, which struck the state on Sept. 12, 1992, caused severe damage to speciality fruit production on Kauai.

Editors: C. L. Chia, Extension Specialist in Horticulture
D. O. Evans, Research Associate
Department of Horticulture
College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

Cover: the oriental fruit fly, *Bactrocera dorsalis*, on lychee; photo courtesy of Dr. Vince Jones; see pages 23-30.

SECOND ANNUAL INTERNATIONAL TROPICAL FRUIT CONFERENCE

Co-sponsored by the Hawaii Tropical Fruit Growers and CTAHR
Hilo Hawaiian Hotel November 13-16, 1992

OPENING NIGHT RECEPTION

Friday, November 13, 1992

4:00 - 5:30 pm	Registration
5:00 - 6:00	No host Cocktails and Pupus
6:30 - 7:15	Mr. David Silber, slide show, "California Tropical Fruits"
7:30 - 8:15	Dr. Jonathan Crane, University of Florida, Tropical Fruit, Crop Specialist, slide show "Overview of Florida Tropical Fruit Industry"

CONFERENCE and ANNUAL MEETING

Saturday, November 14, 1992

8:00 - 9:00 am	Registration
9:00 - 9:15	Opening remarks from the HTFG president, Eric Weinert
9:15 - 9:30	Welcome from the Mayor's Office
9:30 - 10:30	Dr. Johnathan Crane, "Cultural Practices on Atemoya, Carambola, Lychee, and Longan"
10:30 - 11:00	Fruit juice break
11:00 - 11:30	Dr. Eric Jang, USDA/ARS, "Commodity Treatments of Tropical Fruit for Export from Hawaii"
11:30 - 12:00	Ms. Gloria Wong, "HTFG Marketing Plan"
12:00 - 1:30 pm	Lunch
1:30 - 2:00	Dr. Vince Jones, UH Manoa, "Pest Management and Research on Lychee"
2:00 - 2:30	Dr. Robert Paul, "Post Harvest Research on Atemoya, Carambola, Lychee and Rambutan"
2:30 - 3:00	Mr. Bart Jones, "LISA (low input sustainable agriculture) Tropical Fruit Crop Projects"
3:00 - 3:30	Mr. Michael Howden and Mr. John Pollack, "Permaculture Designs for Tropical Fruits"
3:30 - 4:00	Fruit tasting and juice break
4:00 - 4:30	Annual Meeting
6:00 - 7:00	No host cocktails
7:00	Banquet dinner and plant auction

FIELD TOUR

Sunday, November 15, 1992

8:00 am	Bus pickup at Hilo Hawaiian Hotel
8:30 - 11:00	Dr. Philip Ito, tour of University of Hawaii Tropical Fruit Experiment Station at Waiakea Dr. Francis Zee, tour of National Germplasm Repository for Tropical Fruits
11:30 - 12:00	Dr. Joe DeFrank, Low Input Sustainable Agriculture Reseach Project Field Tour, "Fertilization through Mulching and Sod Management in a Carambola Orchard."
12:00 - 1:00 pm	lunch at "Plant it Hawaii, Inc."
1:45 - 2:45	Delan and Jennifer Perry,tour of "Kapoho Grown" tropical fruit farm and "Volcano Isle Fruit Co.
3:30	return to Hilo Hawaiian Hotel

TABLE OF CONTENTS

Welcome Addresses
Leslie Hill 1
Eric Weinert 1
Hawaii County Mayor's Office 2

Exotic Fruits in California
David Silber 3

Florida's Tropical Fruit Industry
Jonathan Crane 5

Cultural Practices for Tropical Fruits in Florida
Jonathan Crane 9

Commodity Treatments of Tropical Fruits for Export from Hawaii
Eric Jang 17

HTFG Marketing Plan
Gloria Wong 20

Progress Towards Pest Management in Litchi
Vincent P. Jones, Carrie H. M. Tome, and Christopher J. Robb 23

Postharvest Handling of Hawaii's New Tropical Fruit Crops
Robert E. Paull 31

LISA for Hawaii Project
Bart Jones 36

Permaculture in a Sustainable Future
John Pollack 38

"Mow and Blow" Field Day at Plant It Hawaii
Joe DeFrank 40

Appendixes
1. Papaya Tree Nursery Retail Plant List 41
2. HTFG Strategic Marketing Plan Development Program Interactive Worksheet 43

WELCOME ADDRESSES

Leslie Hill
President, East Hawaii Chapter, Hawaii Tropical Fruit Growers

Our conference is sponsored by the Hawaii Tropical Fruit Growers and the College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa. Nineteen ninety-two has been a rugged year for a lot of people. Agriculture has been struggling to keep a strong hold and gain some ground. Hurricanes have had devastating effects. The association has gone through a lot of changes, and I hope that you will all stay for the annual meeting this afternoon, where we will go over a few of the changes and bylaws.

The board of directors yesterday made some sweeping changes in the bylaws to open the association to everybody in the state involved in tropical fruits, as well as create new categories for international members and associate members. I think everyone should be very happy with the new changes. Our top priority for this coming year will be to strengthen the organization. Our administrative assistant, Linda Huffman, has been doing a wonderful job organizing the membership database and is available to help strengthen all the chapters in the organization.

Eric Weinert
President, Hawaii Tropical Fruit Growers

Agriculture in Hawaii is at a crossroads. The sugar industry is in trouble; the Hamakua coast is experiencing layoffs. A lot of people are proclaiming agriculture dead. There is no plan to save or fix our agriculture. Government funds are shrinking. I believe that the tropical fruit industry represents an opportunity in diversified agriculture that is already well under way. With that opportunity comes a responsibility for us farmers to work together to build our organization and our industry.

We are a strong group, and we have done a lot in a short period of time. We're a young group. We have recently made some bylaw changes that will open up the organization's structure so that we can get wider participation. An organization does not go on its own; it takes people giving time and energy to support it. The farmers who think they can sit back and farm and have marketing problems and interactions with government agencies take care of themselves are mistaken. We need your participation and support. I encourage you to join this organization and participate, and convince others to join as well.

The organization is the place where the industry interfaces with government. We want to form a partnership with the government agencies that are there to help us. We need a strong organization, one with members who participate, to be an effective group to get attention from those agencies. There is a lot of competition for the funds and resources available. If we want our problems solved, we need to work to make this organization strong.

In addition to joining, we need your personal effort. Pick some thing that you can do to help, and offer it. We have the organizational structure so that everyone's voice can be heard; now we need your participation.

A number of people from government agencies are here today who have been very supportive, and we want to encourage a positive relationship. Please understand that sometimes farmers are impatient. We don't get paid on a weekly basis. We only get paid after we have grown crops, weathered all the bugs, been to see the bankers, and when we finally harvest the crop and sell it, 60 to 90 days later we get a check. So, we're real results-oriented. We want to work with the innovative people in government in a partnership to make agriculture and especially tropical fruits become a base industry, a strong, revenue-

producing, job-creating industry in Hawaii. We look forward to working with you this coming year.

Many of these people will be explaining to us today the work that has already been done on behalf of our organization. I hope they can leave with us an idea of the direction we should take and the things they think need to be done to move this partnership forward.

This afternoon we will elect a new board of directors, who will be setting our agenda. We look forward to all of your inputs to help set that agenda. Let's all work together so that all of us can prosper together.

Kenneth Hupp
for the Hon. Lorraine Inouye, Mayor, County of Hawaii

I appreciate this opportunity to join you today on behalf of the Mayor, who had a prior commitment. She has asked me in her absence to pass along her very warmest greetings and share with you the following message.

It is my extreme pleasure to welcome each and every one of you to the Second Annual International Tropical Fruit Conference. I am confident that this year's conference will be extremely useful and informative. There is no question that this industry has enormous potential here on the Big Island. Given our large land inventory, soil quality, and climatic conditions, the picture indeed looks bright. When you also consider the plight of sugar, which has given a major boost to diversified agriculture, and the recent adoption of a strategic plan for the agricultural industry, the opportunities would appear endless. That is why a conference of this nature is so important. If this industry is to fulfill its potential, it must develop the proper strategies to take advantage of these favorable conditions and to find ways to overcome the challenges that most certainly lie ahead.

During this gathering, you will hear from experts on such topics as commodity treatments for export, marketing, and pesticide research. You will also participate in field tours which include the UH agricultural experiment station, tropical fruit farms, and a commercial drying facility. I am confident that these presentations and field tours will provide a valuable exchange of information that will be of tremendous benefit to this industry.

But, as they say, "All work and no play . . . ." It is also my hope that those of you who are visiting us will take the opportunity to enjoy the breathtaking beauty of the island and the warm hospitality of our people. There is truly something for everybody on the Big Island, where you can enjoy the sun, the snow, and surf all in one day. Wherever you go, I am sure your experience will produce many warm memories that will last a lifetime. On behalf of the County of Hawaii, I wish all of you a successful conference and a very memorable visit to our island. Mahalo nui loa.

EXOTIC FRUITS IN CALIFORNIA

David Silber
Papaya Tree Nursery, Granada Hills, California

My wife Tina and I own and operate a backyard nursery in Granada Hills, a suburb of Los Angeles in the San Fernando Valley. We offer 65 different kinds of exotic fruit and spice trees (Appendix 1). With many of the obscure fruits, marketing them is a bigger challenge than growing them, and takes a lot of effort because in direct-marketing you have to do the promotion work on the spot. But we like to do that; we're enthusiastic.

[Editor's note: Mr. Silber's slide presentation is organized in transcription into a series of notes on species.]

Pitahaya (*Hylocereus undatus*). The exterior is iridescent, waxy, purple; the interior has white flesh, many little black seeds, flavor reminiscent of watermelon: crispy, very refreshing. We sell these at farmer's markets and can get up to $5 for a single fruit. Other *Hylocereus* species such as *H. polyrhizus* and *H. ocamponis* (red fleshed) produce good fruit. There's a yellow-fruited *Mediocactus megalanthus* which you have here in Hawaii that's reputed to be even sweeter. We grow pitahaya on a trellis. We have to pollinate *H. undatus* and *H. polyrhizus* by hand with pollen from another species.

White sapote (*Casimiroa edulis*). We grow 'McDill', a large-fruited variety.

Cherimoya (*Anona cherimoya*) 'M&N' is a cultivar that has done well in hot interior valleys of California.

Babaco (*Carica pentagona*) has fruited here in Hawaii at 1400 ft elevation in Kona. The fruit is called "babaco papaya" but is not a papaya as you are used to them. It has a wonderful, aromatic aroma reminiscent of pineapple and banana, juicy, not sweet, no seeds, edible skin; a processing-type fruit for punches, pies, confections; it tolerates freezing temperatures down to 28°F. This plant bears fruit from ground level up. They don't like high-intensity light, so I put up shade cloth to keep the sun off them. They grow better near the coast in Southern California than they do in the hot interior areas.

Tropical guava (*Psidium guajava*). We grow 'Indian Red' (sweet, pink flesh); 'Turnbull' (white, smooth flesh); also 'Frankel'.

Kiwi (*Actinidia chinensis*). We have a low-chill cultivar called 'Vincent', an excellent fruit that may do well at higher elevations in Hawaii.

Feijoa (*Feijoa sellowiania*) 'Nazemetz' is grown and sold commercially in Southern California; it doesn't brown, has high sugar content and a pineapple flavor.

Carob. *Ceratonia ciliqua* var. 'Santa Fe', The plant is hermaphroditic; the fruit has high sugar content, 12 percent protein; was once considered for commercial production in California; a nice snack food if you have good teeth.

Persimmon (*Diospyros kaki*). We have a backyard variety, not the Jiro type like you see in the market; it tends to be darker orange, larger than the commercial types.

Surinam cherry (*Eugenia uniflora*). Two high-quality cultivars in California also available in Hawaii are 'Vermillion' (very sweet, large, non-acid) and 'Lolita' (small black fruit, excellent flavor, very prolific). Grafted plants will fruit at a small size. Grafting is much superior to seedlings.

Bananas (*Musa* sp.) can be grown in parts of Southern California. There is a commercial banana orchard, Richardson's Seaside Banana Garden, with 11 acres in cultivation including the Hawaiian "apple" (the 'Brazilian'), 'Mysore', and 'Ice Cream', grown organically. I am evaluating bananas for cold tolerance, because I get snow sometimes. I had a 50-pound bunch of 'Monthan' that blew over before it matured, unfortunately. 'Apple' or 'Manzano' banana, which is not your Hawaiian "apple" banana, is excellent if sliced and sauteed in margarine with a little cinnamon powder on it.

Starfruit (*Averrhoa carambola*). I can't fruit starfruit very well at my location, but a hobbyist who lives three miles from me gets prolific fruiting from four trees in her yard.

Papaya (*Carica papaya*) usually doesn't ripen in my area, but can be produced in some parts of California.

Mango. *Mangifera indica.* Mangos are a tenuous prospect in California, requiring extra protection especially during the first three or four years, such as growing in containers or with structures over them. About 5 percent of Southern California has weather benign enough to grow mango without going to all that trouble. Mango is bush-like in California; it doesn't become a large

tree. 'Thomson' mango was selected by Paul Thomson; it is a Manila or Indochinese type, anthracnose resistant, early bearing, very high quality, that does well in coastal regions and some interior locations. We also grow 'Edward'. There is a 100-acre commercial orchard of 'Keitt' mango developed by Sun World in the inland area near the Salton Sea where it is very hot, similar to the Jordan Valley of Israel, and they have Israelis advising them. They are exporting mangos to Tokyo. In California, our mangos ripen from September through December, which is after the main crop of many producing countries, so growers can set prices, rather than the distributor.

Fig (*Ficus carica*) 'Panache' has a striped fruit with excellent quality. It was part of a collection assembled at UC Riverside in an unsuccessful attempt to select a replacement for the Smyrna fig, which is grown for drying. Ira Condit and William Storey, who was here at the University of Hawaii for awhile, put together the collection, but after they retired it was bulldozed, so now the cultivars are in private collections.

Jaboticaba (*Myrciaria cauliflora*) does well in the San Francisco bay area but doesn't tolerate the soil alkalinity and salinity in irrigation water that we have in Southern California.

Apple (*Malus* sp.) 'Dorset Golden' is a low-chill cultivar selected in the Bahamas that requires less than 100 hours winter chill.

Loquat (*Eriobotria japonica*) 'Big Jim' is a large, sweet, orange-fleshed fruit that approaches plum size; it sold very well for us this spring at $3.00/lb. We had to bag the clusters of fruits against sunburn and birds to get good quality; the skin quality was much improved due to the bagging. 'Mrs. Cooksie' is a larger fruit but the flavor is more insipid. They are susceptible to fire blight. I spray a copper fungicide or Bordeaux mixture on the flowers in the spring; this reduces risk of the disease. Bees are the fire blight vector.

Lychee (*Litchi chinensis*) grows in Southern California, and 'Brewster' is our best cultivar. We get crops every two or three years.

Cherimoya (*Anona cherimola*) 'White'. California Tropics orchard in Ventura County packs white sapote, passion fruit, feijoa, and cherimoya. They have a modern packing facility and they sell premium quality cherimoya to Japan for premium prices.

Pepino dulce (*Solanum muricatum*) 'Temptation' tastes something like a Crenshaw melon only with a more flowery aroma.

Wampi (*Clausena lansium*) does well in California; fruits sell well in Chinese neighborhoods. I like those with sweet-tart flavor.

Asian pear (*Pyrus pyrifolia*) grows well in Southern California throughout the Central Valley.

Cudrania tricuspidata. The common name is "che," which is northern Chinese. We call it the Chinese mulberry. This has caught on in the southeastern part of the U.S., and we got our stock from Georgia. It's sweet and juicy if allowed to ripen to perfection, reminiscent of fig; a warm-temperate zone plant that tolerates freezing temperatures to some extent. A dioecious shrub which I propagate from cuttings.

Woollyleaf white sapote (*Casimiroa tetrameria*) 'Max Golden' differs from the white sapote; it fruits earlier, has pubescent leaves, flesh is very sweet with a turpine-like aftertaste. We pulp the fruit, freeze it, and use it to flavor milk shakes. We sell grafted plants.

Kie apple (*Dovyalis caffra*) 'Arcadian' gets very sweet if allowed to ripen until the skin is somewhat translucent; it has an apricot-like flavor, juicy and sweet. I've shipped these to Japan and they were well received. It's a subtropical, heavy bearing, dioecious plant with long thorns, used for lion-proof fencing for corrals in Africa. I have been growing them as an espalier to try to deal with the thorniness.

Pawpaw (*Asimina triloba*), the true pawpaw, is a native American fruit that grows from Florida to Michigan. The fruit resembles cherimoya in flavor, very seedy but delicious. There are selections, and there are nurseries that graft them. It has been grown in California, but I don't grow it.

Chinese jujube (*Zizyphus jujuba*). Several orchards have been planted in Southern California. The Vietnamese people buy it if picked crisp-ripe; it's usually sold in Chinese stores dried for use in soups. I like it when it is half-green, half-brown; it's something like an apple, with a pleasant acidity differing from the acidity of apples. The plant likes hot, dry conditions. 'Lee' and 'Lang' are two cultivars. Koreans like it too. I've noted that Americans who try it like it; especially, children really go for it.

FLORIDA'S TROPICAL FRUIT INDUSTRY

Jonathan Crane
Tropical Research and Education Center
Institute of Food and Agricultural Sciences, University of Florida

During Hurricane Andrew we lost 35 to 40 percent of our tropical fruit crops acreage, but we anticipate that most of it will come back. My comments on the industry will generally refer to its status currently and prior to the hurricane.

Tropical fruit crops are grown on a commercial scale in Florida primarily in Dade County, but we can generally grow them south of Lake Okeechobee (Fig. 1). Dade County has about 22,000 acres (Fig. 2). There's some small acreage in Broward County, Collier County has about 600 acres, and Lee County has about 1,000 acres on Pine Island. Florida has an extensive canal system originating from Lake Okeechobee which was begun after the 1926 hurricane to control flooding and to open up the southeastern coast of Florida for agriculture and urbanization. They're still adding to the canal system. The state has five water management districts. In southern Dade County the water table is about 8–10 ft below the soil surface.

The major crops in Dade County are avocados, 'Tahiti' limes, and mangos, which collectively account for about 90 percent of the tropical fruit crops acreage in south Florida; minor tropical fruit crops account for about 10 percent of the acreage. Florida is the top U.S. mainland producer of mango, carambola, lychee and longan, mamey sapote, atemoya, sugar apple, and passion fruit. We're the number two producer, behind Hawaii, of papaya, banana, and guava.

We have a marine subtropical climate and are located between 25 and 27 degrees north latitude. We are surrounded by water on three sides which moderates our temperature extremes. Our mean yearly temperature is about 74°F and the coldest months are December, January, and February. Statistically there is one chance every year of reaching 32°F or below. Last year we didn't go below 39°F; in 1989 we went below 32°F four nights in a row. Mean annual rainfall is about 65 inches with a wet season from May to October and a dry season from October to May. Evaporation exceeds rainfall 11 months of each year. There is a possibility of hurricanes from June to November.

There are a number of factors that have facili-

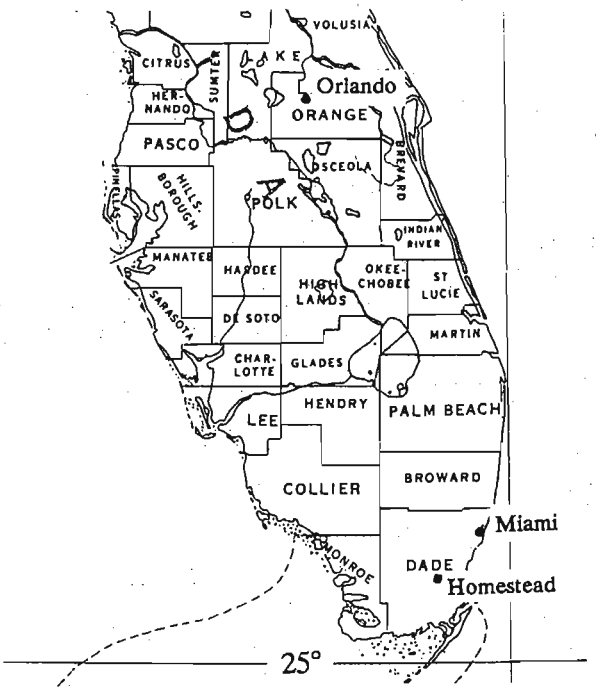


Figure 1. Counties of southern Florida.

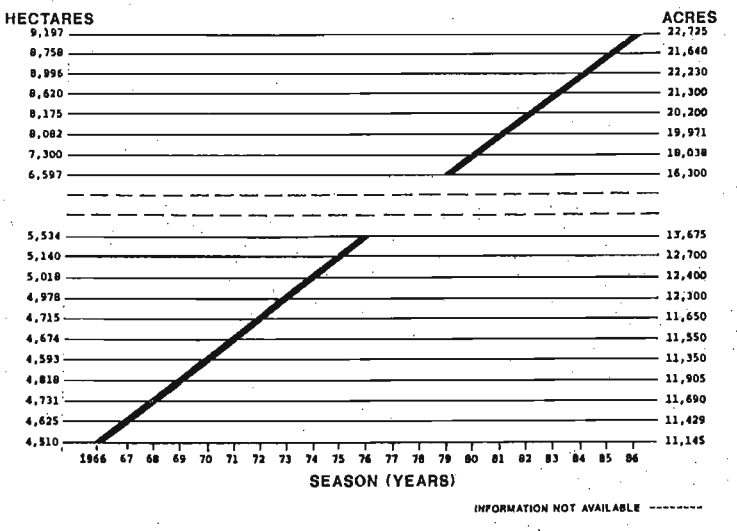


Figure 2. Tropical fruit acreage in Dade County, Florida, 1966–1986.

tated development of the tropical fruit industry in Florida including our large ethnic populations familiar with tropical fruits. For example, of 1.2 million people in Dade County, 51 percent is Hispanic, many from Central and South America and Cuba. The rest of the population is about 30 percent Euroamerican and about 20 percent black (some from the Caribbean). We also have a substantial Asian population. We have a lot of entrepreneurial producers and packing houses. J.R. Brooks and Sons has been a leader in promoting and taking marketing chances on tropical fruits. Our growers do a lot of homework, researching our ethnic populations and putting in test plots of fruits they might like.

Florida has a long history of introducing tropical fruit crops plant material. The USDA Subtropical Horticultural Research Station and Germplasm Repository in Miami has introduced thousands of fruit crop species and cultivars since the early 1900s. The Tropical Research and Education Center, part of the University of Florida, has been introducing fruit crop species since the 1930s. Also, a lot of private nurseries and individuals have brought and continue to bring in plant material for evaluation for commercial production. The state and some private sources provide funds for research and development. We are active in the IR-4 Program that coordinates activities among USDA, land grant institutions, pesticide companies, and producers to register pesticides for minor crops. There are also some agricultural tax exemptions.

Our industry has had gross annual sales of about $74 million for the past three or four years. Total worth of the industry is about $128 million to the state, adding in fertilizer and equipment sales, etc. About 88 percent of production is shipped out of the production area. Dade is number two of 67 Florida counties in agricultural receipts, which is especially impressive in comparison with our citrus counties. Palm Beach County is number one in agricultural income and they grow sugarcane. Dade is the most populated county, with only 86,000 acres available for agriculture, of which about 22,000 is in tropical fruits. Agriculture, all crops combined, in Dade County is worth almost $1 billion annually.

Commercial grower organizations include Tropical Fruit Growers of South Florida, Inc., a group oriented toward commercial growers, the Florida Mango Forum, Agricouncil, and the Dade County Farm Bureau. The lime and avocado industries are both under federal and state marketing orders, with their own administrative committees.

Growers in South Dade are very diverse and sophisticated. Average farm size is 10 acres. A typical grower might concentrate on one or two crops, but some are more diversified. Our zoning laws at present do not allow for less than 5-acre lots, but there seem to be a lot of variances granted for one reason or another.

To summarize our advantages, we have a good climate for growing tropical fruits and a diverse ethnic population to jump-start introduction of exotic crops. Also, people today are more willing to try exotic fruits, and people's diets are changing to include more fruits and vegetables. Our research station has one of the highest records of grower-funded research in the state of Florida, until very recently even higher than the citrus industry, which is a $3-billion industry. The tropical fruit crops industry has been funding an array of research. For example, the carambola growers are funding work on nutrition and flowering, the lime committee has funded various research projects at a $100,000-per-year level, and the avocado committee has funded substantial research as well.

Recently, the Florida legislature passed the Tropical Fruit Crops Act. As a result, the Commis-sioner for Agriculture and Consumer Services appointed a Tropical Fruits Advisory Council to devise a plan to develop and assist the industry. The plan hasn't yet been funded, but the Council is very persistent.

Most of Dade County's tropical fruit crops are grown on what we commonly call Rockland soil, more technically called a Krome very gravelly sandy loam. Essentially, it's solid limestone rock with a half inch or so of "soil" on top. To grow crops, we have to prepare the soil with a "rock plow" that scarifies the rock about ¼ to ½ inch at a pass. They scrape until they get from 6 to 12 inches of crushed rock that is a mixture of organic matter, clay, and oolitic limestone. Then they bring in a trencher that goes in a grid pattern on the field at the desired row spacings. They mark the intersections where the trenches cross and then backfill the trenches. After auguring holes at the intersections, the tree are planted. These practices increase the soil volume for root activity, affecting water and nutrient availability and tree stability. It's an improvement over what we call "flat planting," where holes are made with a pick or a quarter stick of dynamite.

Avocado

We had about 9,000 commercial acres, and the industry was worth about $18 million a year. We grow 62 varieties commercially, 28 of which are major varieties, based on volume. Most are Guatemalan-West Indian hybrids, with a diversity of shapes and sizes. The season ranges from June through March. We go through our season by changing cultivars, whereas California grows essentially one cultivar and extends its harvest season by harvesting fruit from different locations throughout the state.

Lime

We had about 6,800 acres of commercial 'Tahiti' limes in Dade County, producing about 98 percent of all the limes grown in the U.S. and about half of all the limes consumed in the U.S. The industry was worth $30 million a year. We lost about 60 percent of the lime acreage in Hurricane Andrew. The major rootstock is *Citrus macrophylla*; rough lemon (*C. jambhiri*) has also been used in the past. A large amount of the acreage that was lost in the hurricane had been developed from air layers. They blew right out of the ground and some were found as far as three miles away. I call them the new Florida tumbleweed.

Mango

We had about 3,000 acres and lost about half in the hurricane. It had been worth about $18 million a year. 'Keitt' is the major late cultivar that we grow; 'Tommy Atkins' is the major early cultivar. Many of the major commercial cultivars developed in Florida are now grown throughout the world. The Florida Mango Forum was involved for many years in evaluating and selecting seedling mangos grown throughout South Florida. 'Tommy Atkins' had been brought in and rejected as a commercial variety for several years when the Mitchells saw its potential and started producing it. 'Van Dyke' is a smaller fruit that is also grown commercially. 'Valencia Pride' and 'Kent' are grown to some extent. 'Sensation' is no longer grown commercially. Some growers are experimenting with Asian types of mangos.

Banana

We have about 500 acres of commercial banana production. 'Manzana' is the dominant variety, but a lot of the acreage is being lost due to Panama disease. 'Hua Moa' and a number of others are grown. Most of the production is consumed locally.

Carambola

Almost all of our 500 acres of carambola survived the hurricane intact, to our surprise. We usually grow it in wind-protected sites with either natural or artificial windbreaks, and that may have helped. Virtually every tree was defoliated, but it seemed to take the hurricane fairly well. About 98 percent of the acreage is planted to the 'Arkin' carambola, but growers are experimenting with others. 'Golden Star' was selected at the University of Florida by Carl Campbell. It is a tart type that does get sweet if allowed to ripen on the tree. 'Fwang Tung' is grown in many dooryards, but on only a very small scale commercially; its color is considered too light and its fins too large. 'Kary' is being grown on a small scale. 'B-10' is being evaluated. We were packing about 4 million pounds of fruit with a value of $1.5–2 million. We protect the trees from freezing temperatures with water (irrigation), and with trees over five years old we do get some splitting from the weight of the ice, but we do not see the kind of propensity toward limb splitting in the 'Arkin' cultivar that some of you mentioned.

Mamey sapote

More than 300 acres are grown. It takes from 13 to 24 months from flowering to harvest. The fruits bring $2–3/lb to the farmer, $3–5/lb retail. It is very popular with the Cubans. The 'Magana' cultivar gets up to about 8 lb per fruit. A number of cultivars are grown; we have 13 at our station. Mamey groves came through the hurricane quite well. They lost most of their major upper scaffolding limbs, but most trees are still standing and flushed out immediately after the storm. We had a freeze in 1989 that destroyed the crop, which meant that two to three years later we expected a large crop. Now we have had a hurricane and we have to wait another two years.

Papaya

Lately we've had 250–300 acres; formerly we had up to 1,000 or more, but with the introduction of papaya ringspot virus and the papaya fruit fly, the industry decreased dramatically. We cannot grow Solo type papayas, so we grow hybrids and some of the Thai types. It is grown mostly as an annual, for one season, often for green fruit for chutneys rather than for the fresh fruit market.

Lychee

About 200 acres. We had a very large crop this season. The two main cultivars are 'Mauritius' and

'Brewster' (55 and 45 percent of the acreage, respectively). Hurricane damage was much more severe on the 'Mauritius'.

Longan

We grew the largest longan crop in the continental U.S .this year. 'Kohala' is the main cultivar but unfortunately it's an unreliable bearer, with a commercial crop once in three or four years. However, this year was an "on" year, estimated at 3–4 million pounds. There are about 100 acres, and probably more will be put in.

Atemoya

We have about 150 acres of 'Gefner' atemoya. Cherimoya does not do well in our area.

Sugar apple

We have about 100 acres. It is used as an interplant in the mamey sapote groves. It gets to 25 ft in height and 20–25 ft spread. The major problem with it and the atemoya is the annona seed borer and a short postharvest life.

Passion fruit

We had about 110 acres with more going in prior to the hurricane. It is usually grown on trellises about 6–7 ft high. 'Possum purple', a hybrid between yellow and purple types, is the major cultivar. So far we don't have any of the major viruses.

Guava

We have about 77 acres, with another 20–40 acres planned this year. It is all for the fresh fruit market. 'Ruby Supreme' is one of the major cultivars.

Wampi

A little bit is grown commercially but mostly as a border tree around groves rather than a solid planting.

White sapote

White sapote is a very minor commercial crop at the present time.

Key lime

We have 20–25 commercial acres. Key limes have several diseases that kill the new growth and can make fruit production difficult. It also has large thorns, which doesn't make pickers happy.

Sapodilla

About 15 acres, and a number of cultivars.

Canistel

Also grown on a small scale and has a number of different cultivars. It's an excellent fruit if allowed to ripen properly.

Kumquat

Kumquat is grown on about 25 acres, is a very cold-hardy tree, and the fruit brings a good price. 'Nagami' is grown more than 'Meiwa'.

Jackfruit

We have about 3 acres commercially; some of it is consumed locally but some gets shipped as far away as Texas, where there are populations of Vietnamese, who are very familiar with it. The biggest problem on our station with jackfruit was theft, which did occur even though the fruits weigh up to 35-40 lb. We would paint them orange with scull-and-crossbones, but they would disappear anyway.

Barbados cherry

This is grown on about 27 acres with 20 more acres intended. 'Florida Sweet' and 'B-17' are the two major cultivars. The fruit is too fragile for the fresh market. It is mostly processed for juice, some of which, I believe, is exported to Germany for use as a natural vitamin C additive.

Pummelos

We probably have 25 acres. I feel this crop has a lot of potential and the market has not been touched. The USDA station in Orlando, not the one in Miami, has a large cultivar collection which we would like to see grown a little closer to us, as Orlando is a bit marginal climatically for pummelo.

Others

Jaboticaba is grown on about 1 acre commercially, but it is slow growing in our area. **Wax jambu** is grown on perhaps 1 acre total. **Black sapote** is grown on a very small scale. **Monstera** is often grown on borders along fences. **Tamarind** appears in the markets, mostly tart varieties. A little **loquat** is grown and sold; the major problem is the Caribbean fruit fly.

CULTURAL PRACTICES FOR TROPICAL FRUITS IN FLORIDA

Jonathan Crane
Tropical Research and Education Center
Institute of Food and Agricultural Sciences, University of Florida

Mango

Mangos are well adapted to the tropics and subtropics. Mature trees can tolerate temperatures down to 25°F for a few hours with some leaf and twig injury, whereas young trees can be killed by temperatures of 29–30°F. The fruit and flowers can be killed after a few hours at 40°F, and sometimes that is a problem in our area. Research at the University of Florida in Gainesville showed mangos do not acclimate to cold temperatures like citrus and that Florida cultivars do not show any difference in cold tolerance.

There are two types of mangos, Indian and Indonesian. Indian types are usually monoembryonic, with highly colored fruits susceptible to anthracnose, and some to internal breakdown. Most of the commercial Florida cultivars are Indian types and our major problem is anthracnose. There are Indonesian types grown in small plantings in Florida; these are usually polyembryonic, with yellow or green fruit and relatively resistant to anthracnose.

We have about 2,800 acres with 277,000 trees. Eighty-five percent of the acreage is in Dade County. Estimated production is about 500,000 bushels (27.5 million pounds) per year. The industry is worth $14–18 million recently. We are the number one producer in the U.S., but we only supply 17–21 percent of the U.S. market. Most of the rest comes from Mexico, Central America, and the Caribbean.

Most mango is planted on our limestone soils, which are 8–25 ft above sea level. These soils have a pH of 7.5–8.5, very low cation exchange capacity, low organic matter content, and low moisture holding capacity. There is some production on our sandy soils, mostly in Lee County, where the soil pH is more acid. Mango trees tolerate some flooding, and research at our station has found that where trees are grown on mounds in flood-prone areas, they tolerate from a few days to three or four weeks of flooding. The water in our flood-prone areas is moving rather than stagnant and is therefore oxygenated, which aids survival. Flooding symptoms include lower leaf wilting, desiccation, stem dieback, decreased growth, and death.

Monoembryonic mango cultivars are not propagated by seed because the seedlings are not true to type and have a long juvenile period. Veneer grafting and chip budding are the most common propagation techniques. Air layering has been done for flowering studies but is not used for commercial planting. We use mostly 'Turpentine' and 'No. 11' seeds for rootstock. These rootstocks have been observed to be tolerant of high soil pH and relatively vigorous. We haven't done a lot of research on rootstocks. 'Haden' used to be the number one commercial cultivar, but no longer. Now 'Tommy Atkins' is the main early cultivar and 'Keitt' is the main late one (Table 1).

Mango plant spacings vary from 10 to 30 ft in-row and 20 to 30 ft between rows. The closer spacings get, the more intensive the production practices, especially tree size control. We hedge to leave a 5–8 ft middle, and we top at 16–18 ft. The best time for this is immediately after harvest. This is because it allows the new growth time to mature in time to flower and fruit the next year. If you wait to hedge or top, you may get two vegetative flushes or delay the flush so that it will not mature in time for flowering the following year. Some people have programs where they hedge or top every other row or every third row every year, so if the pruned parts stay vegetative the nonpruned parts of the trees are not out of production entirely. Hedging and topping may reduce subsequent production. Topping machines typically used in the citrus industry are used and can cut flat or at an angle. These machines move rapidly through the grove and are very noisy. We are hoping to get funds to look at different sequences and methods of topping and hedging to develop an ideal method for pruning.

Flowers are initiated in the fall, and flowering can occur from December through April. Sometimes we get multiple flowerings and can have two distinct crops on a tree. It is temperature dependent. Pollination is by thrips, flies, and honey bees to a small extent. Our harvest season runs from May to September–October, with the main crop in June and July. It takes 100–150 days from flowering to maturity.

Fertilizer applications for young trees may be

Table 1. Some characteristics of Florida mango varieties.

Variety	Fruit maturity[1]	Fruit weight (oz)	Fruit color[2]	Production[3]	Anthracnose susceptibility[4]	Seed type[5]	Recommended for[6] Home	Commercial
Earlygold	M J	10–14	Pi Y	F	MR	-	Y	N
Florigon	M J Jl	10–16	Y	G	MR	P	Y	N
Saigon	M J Jl	6–12	G Y	G	MR	P	Y	N
Zill	M J Jl	8–12	R Y	G	S	M	Y	N
Edward	M J Jl	16–20	Y Pi R	P	MR	M	Y	N
Glenn	J Jl	12–18	Y Pi R	GF	MR	M	Y	N
Haden	J Jl	16–24	R Y	F	S	M	Y	M
Irwin	J Jl	12–16	R	G	VS	M	Y	M
Carrie	J Jl	10–12	G Y	GF	MR	M	Y	N
Julie	J Jl	12–16	G Pi Y	P	S	M	Y	N
Van Dyke	J Jl	10–16	R Y	G	MR	M	Y	Y
Tommy Atkins	J Jl	16–24	R Y	G	MR	M	Y	Y
Lippens	J Jl	14–20	Pi Y	G	S	M	Y	N
Adams	J Jl	6–10	R	G	S	M	Y	N
Fascell	Jl A	12–18	Pi R Y	G	S	M	Y	N
Ruby	Jl A	6–8	R	G	S	M	Y	N
Smith	Jl A	16–32	R Y	G	S	M	Y	N
Kent	Jl A	16–30	G R Y	G	VS	M	Y	M
Palmer	Jl A	20–30	R Y	G	S	M	Y	Y
Sensation	Jl A	10–12	P R	G	S	M	Y	N
Keitt	A S	20–40	G Pi Y	G	MR	M	Y	Y

[1]Fruit maturity: M = May, J = June, Jl = July, A = August, S = September.
[2]Fruit color: G = green, P = purple, Pi = pink, R = red, Y = yellow.
[3]Fruit production: G = good, F = fair, P = poor.
[4]Anthracnose susceptibility: MR = moderately resistant, S = susceptible, VS = very susceptible.
[5]Seed type: M = monoembryonic, P = polyembryonic; Earlygold: majority of fruits seedless.
[6]Recommendation: Y = yes, N = no, M = maybe.
Source: Crane, J.H., and C.W. Campbell. 1991. The mango. FC-2, Fla. Coop. Extension Service, IFAS, Univ. of Fla., Gainesville, FL.

every 4–8 weeks, beginning with about ¼ lb and increasing up to 1–1½ lb over the first three years. Mature trees get two to four fertilizer applications per year. Some of the larger producers usually fertilize twice a year. Nutrient ratios vary; a common one is 8-3-9-3 (N-P-K-Mg). Because of our high soil pH, we have a problem with micronutrient deficiencies of manganese, zinc, and iron. In the more acid soil areas micronutrients can be applied to the soil, but on calcareous soils they have to be applied in foliar sprays, usually three to four times a year. Chelated iron is applied as a soil drench. We irrigate first, apply the iron, and then irrigate again to move it into the soil before sunlight can degrade it.

Grafted trees will begin bearing in three to five years. Fruit set is low, one fruit for three to five panicles in our area. Anthracnose and other fungal diseases and low temperatures during bloom are the factors most limiting production. Average production is 4–6 bushels per tree, or 400–500 bu/acre, sometimes up to 600–700 bu/acre from mature groves. We've tried many methods to determine when fruit is mature enough to pick, such as sugar and acid content, specific gravity, and size. Fruits are mostly picked green-mature or at color break, but some growers sell tree-ripened fruits. At maturity there is a difference in the shape of the fruit at the shoulders; they fill out and become broader. Internally, the fruits are mature when the flesh near the seed turns from white to yellow, but that's a destructive method of observing maturity. Fruits are picked by hand with picking poles and ladders or hydraulic lifts.

Table 2. Major insects, diseases, and disorders of mangos in Florida.

	Common name	Scientific name	Affects/ attacks[z]
Insect	Red-banded thrips	*Selenothrips rubrocintus*	L
	False oleander scale	*Pseudaulacaspis cockerelli*	L, F
	Pyriform scale	*Protopulvinaria pyriformis*	L
	Dictyospermum scale	*Chrysomphalus dictyospermi*	L, S
	Florida red scale	*Chrysomphalus aonidum*	L, F
	Mites	*Paratetranychus yothersii*	L
	Florida thrips	*Frankliniella bispinosa*	F
	Ambrosia beetles	*Xylosandrus* sp.	S, Li, T
Disease	Anthracnose	*Colletotrichum gloeosporiodes*	L, Fl, P, F, S
	Mango scab	*Elsinoe mangiferae*	L, Fl, F, S
	Powdery mildew	*Oidium* sp.	L, Fl, F
	Verticillium wilt	*Verticillium albo-atrum*	R, S
	Alga spot	*Cephaleuros* sp.	L, S
Disorder	Mango decline	Unknown; associated with fungi, nematodes, nutrient deficiencies	whole tree
	Internal breakdown	Thought related to Ca	F
	Mango malformation	*Fusarium moniliforme*	P

[z]Affects/attacks: L = leaves, Fl = flowers, F = fruit, S = stems, T = trunk, P = panicles, R = roots.
Source: Crane, J.H., and C.W. Campbell. 1991. The mango. FC-2, Fla. Coop. Extension Service, IFAS, Univ. of Fla., Gainesville, FL.

Because of variable flowering times, pickers have to be trained to know which fruits to pick. They may go through a grove several different times to pick the fruits that are ready. Fruits are put in bags and buckets and then in 1,000-lb bins for transport to packing houses. We don't have much problem with bruising or sap burn. Best ripening temperatures are between 70 and 75°F; cold storage temperature should be no lower than 55°F. Chilling injury symptoms include brown or gray skin discoloration, pitting, and off-flavors. This can occur at the retail store if the fruits are laid out on ice.

Major insect problems are red-banded thrips, scales, mites, ambrosia beetles, and false oleander scale (Table 2). Anthracnose and powdery mildew will attack the inflorescence, so we begin our spray program the moment the inflorescence begins to emerge. In drier climates this may not be much of a problem, but if we do not spray from flowering we don't get fruit, and we have to spray all the way to harvest or we lose the fruit. We occasionally see verticillium wilt, algal spot, and stem end rot. Verticillium wilt often occurs where young mangos are planted on land previously planted to tomatoes. It comes on very rapidly and part of the tree dies back, and when you cut into the bark of the affected area you see the dead cambium. Mango decline is another problem and is associated with manganese, zinc, and iron deficiencies, although the cause has not been proven. Fungi and nematodes have also been implicated. Sometimes applying the deficient micronutrients can correct the problem, but in other cases it doesn't help. Internal breakdown (jelly seed, soft nose) is another physiological disorder that affects fruits. Symptoms include breakdown and watersoaking of fruit, an open cavity inside the fruit, overripe flesh, and areas of varying size in the flesh with a spongy texture and grayish color. There is a suspicion that internal breakdown may be related to calcium deficiency, even though we grow mangos on calcareous soils. Mango malformation is caused by *Fusarium moniliformae*. It will start in a grove and then get worse each year. Symptoms include a very compact inflorescence and very few fruits set. The Israelis control this by rogueing affected panicles, but it has to be done consistently.

Table 3. Carambola cultivars introduced into or selected in South Florida.

Cultivar	Origin[1]	Flavor	Recommended use[2]		Comments
			Home	Commercial	
Arkin	Florida	Sweet	Y	Y	Commercially important
B-2	Malaysia	Sweet	U	U	Under evaluation
B-10	Malaysia	Sweet	Y	U	Under evaluation
B-16	Malaysia	Sweet	Y	U	Under evaluation
B-17	Malaysia	Sweet	Y	U	Under evaluation
Dah Pon	Taiwan	Sweet	N	N	Poor color, insipid taste
Demak	Indonesia	Sweet	N	N	Bitter aftertaste
Fwang Tung	Thailand	Sweet	Y	N	Poor color, thin ribs, good flavor
Golden Star	Florida	Tart	Y	M	Sweet when fully ripe, very productive
Hew-1	Malaysia	Sweet	Y	N	Whitish spots on fruit, good flavor
Kary	Hawaii	Sweet	Y	U	Under evaluation
Maha	Malaysia	Sweet	N	N	Poor color, thin ribs, insipid taste
Mih Tao	Taiwan	Sweet	N	N	Insipid taste
Newcomb	Florida	Tart	Y	N	Tart
Sri Kembangan	Malaysia	Sweet	U	U	Under evaluation
Star King	Florida	Tart	N	N	Very tart
Tean Ma	Taiwan	Sweet	N	N	Insipid taste
Thayer	Florida	Tart	Y	N	Tart

[1]Florida cultivars originated from seeds introduced from other countries (e.g. Thailand, Malaysia) or Hawaii (e.g., 'Golden Star').
[2]Recommended use: Y = yes, N = no, M = maybe, U = no recommendation available.
Source: Crane, J.H. 1992. The carambola (star fruit). FC-12, Fla. Coop. Extension Service, IFAS, Univ. of Fla., Gainesville, FL.

Carambola

Carambola acreage has progressed steadily since 1971, with a jump in 1987–88, and has leveled off at about 500 acres. We surveyed the industry in 1989, and 90 percent of the acreage was four years old or less at that time; now 90 percent is seven years old or less.

Carambola is indigenous to Southeast Asia and grows well in hot, humid, wet tropical and subtropical lowland areas. Young trees can be severely damaged at 27–29°F, and mature trees are damaged at 24–26°F. These temperatures are for unprotected trees, because we protect our trees with high-volume irrigation. We have noted wind tolerance differences among cultivars, and our major cultivar ('Arkin') is quite susceptible to wind damage. We have found them to be moderately flood tolerant, surviving (if not growing) up to 18 weeks in experiments where no diseases were present in the media. They are adapted to a range of soil types, as long as the soils are well drained. 'Arkin' is the major cultivar in Florida, and our industry did not take off until it was selected (Table 3).

We recommend wind-protected sites for carambola groves. Many growers use windscreens and grove sites with plantings of taller, more wind-tolerant trees such as sapodilla or avocado. Groves are divided into sections by internal windscreens that keep the wind from dipping back down into the grove. Externally, a border of windbreak trees such as Australian pine may be used. There are about 200 windscreened acres in South Florida presently, costing $4,000–7,000/acre. One windscreened 50-acre planting came into production in 13 months. In another case where an old avocado grove was given over to carambola, some of the avocados were left to provide external and internal windbreaks. We've also seen carambola planted between passion fruit rows that act as internal windbreaks. Papaya has been interplanted with carambola also and is effective because it grows

faster than the carambola. A seven-year-old tree exposed to wind may have very low production of low quality fruit, chlorosis, nutritional deficiencies, and be only six feet tall, whereas a seven-year-old tree in a wind-protected area might get 22 ft tall and be very productive.

Plant spacing varies a lot in the commercial industry. Left unpruned, carambolas will reach 30–35 ft in spread and height, so free-standing trees have to be planted at least 35 ft apart. The industry has tried a lot of combinations, such as 15 x 22 ft, 15 x 20 ft, over a range of from 8 x 8 ft to 30 x 35 ft. Moderate plant densities of 145–190 trees/acre are most common (Table 4). Some people plan to take out every other tree with close spacings, but with moderate plant spacings they plan to manage tree size as they get to be seven to eight years old.

For rootstocks we use open-pollinated seedlings of 'Golden Star' and 'M-18960'. Dr. Bob Knight has studied these and others. He did selfs and crosses and found that those two seedlings used as rootstocks had the least apparent deficiency symptoms on our calcareous soils. Carambola are mostly propagated by veneer or modified veneer grafting (which is actually a bud graft with the shape of a veneer graft). Some nurserymen use T-buds or chip-budding. Air layering has not been successful. In tissue culture they have been able to produce shoots but not roots.

We had not done research to develop fertilizer recommendations until recently when we installed an experiment on rates of nitrogen and iron. Generally, we use four to six applications of a triple-six or 8-3-9. Young trees are usually fertilized monthly. Foliar micronutrient applications and soil drenches are done three to six times a year.

Irrigation is recommended if there are more than seven days of dry weather. Flowering has been shown to be reduced by water stress. We use picking boxes similar to the ones you use here. Fruits are placed, not thrown, into the boxes. Boxes are put into a half-size bin for transport to the packing house.

Carambolas were formerly thought to be pest and disease free, but whenever you have a monoculture, problems start cropping up. Insect pests include stinkbugs, fruit blotch leafminer, red-banded thrips (occasionally), and some scale insects. Nematodes have not been much of a problem. Birds can be a problem early in the season. We see *Cercospora averrhoa* Petch., *Corynespora cassiicola* Berk. and Curt., *Phomopsis* sp., *Gloesporium* sp., and *Phyllosticta* sp. on senescing, mature leaves, especially during cooler weather. During this time tree growth starts slowing down, and these organisms colonize the leaves. Anthracnose is not a big problem. We have a sooty mold different from that found on citrus. It is a *Leptothyrium* sp. and we find no insect associated with it. Pathologists believe that it is living on the wax of the fruit. *Pythium splendens* attacks the roots and causes a general decline in tree vigor. The fungus prefers warm temperatures, but we see the most damage in late winter and early spring. Even though the temperatures are not optimum for the fungus, it can still grow better than the carambolas and gets the upper hand. As spring comes on, the trees tend to come out of their vegetative decline. Affected trees are delayed in the onset of new growth by two or three months. We also find this root pest on atemoya and lychee trees. We are doing IR-4 field studies with metalaxyl (Ridomil) for control. Pot studies have shown efficacy, but we need to confirm that in the field. We have not considered rootstock interactions, but it's a possible approach.

About 69 percent of the acreage has in-row spacings of 10–20 ft, which means that crowding occurs. The growth model of carambola is called the Troll Model, and it not only grows upward but

Table 4. Percent of the total South Florida commercial carambola acres at the ten most common plant densities and spacings.

Plant density	Plant spacing (ft)	Trees per acre	Percent of acreage
Moderate	15 x 22	132	16
Moderate	15 x 20	145	15
Moderate	15 x 25	116	11
Moderate	20 x 20	108	6
Moderate	16 x 23	118	5
Low	25 x 25	69	11
Low	20 x 25	87	7
High	12½ x 25	139	5
High	10 x 15	290	2
High	13 x 20	167	2
Miscellaneous[z]			20

[z]Various plant densities and spacings, none of which account for 2 percent or more of the total carambola acreage.
Source: Crane, J.H., C.W. Campbell, and R. Olszack. 1989. Current statistics for commercial carambola groves in south Florida. Proc. Interam. Soc. Trop. Hort. 33:94-99.

outward. Typically, a branch will grow vertically when vegetative, flower and fruit, then bend down. Buds then will break along this lateral branch and they will grow up and out. The inner branches eventually will defoliate, stop producing fruit, and die back, and you get crowding and lose fruit production. You end up with huge, igloo-shaped areas inside the tree producing no fruit. Some people had tried topping and were horrified by the vegetative response. We have tried selective pruning. We began a trial about two years ago in a five-year-old grove with trees 13 ft tall spaced 12½ ft in the row, so they were starting to crowd and form nonproductive areas on the inside of the canopy. We compared unpruned trees with trees from which we selectively removed any upright limbs. Trees ended up about 10 ft tall. We also had topping treatments where we cut trees back to 7 ft or 9 ft; we did this in February and found that the pruned treatments regrew very rapidly up to about the same height as the control by August or September. Then we repruned, removing about half of all the new growth, and cutting back the remaining new growth about halfway. About 14 months later the trees that had started at 13 ft high and been pruned were again about 13 ft, whereas the controls were 16–17 ft tall, so we could control the height. We found that the major fruit-producing area of the 'Arkin' is the mid-canopy area, from about 3 to 6 or 7 ft on seven-year-old trees. When we pruned we got new vegetative growth above, but it did not decrease flowering or fruit production below the pruning cut, so we did not lose production in that area, which is where picking is most convenient anyway. We are also trying topping trials, because with the citrus machinery available in our area this technique is very fast. If we don't adversely affect the fruit production in the area where picking is going to occur, then it may not matter what is happening above that area.

Wind can adversely affect carambola tree growth, fruit production, and fruit quality. South Dade's windiest months are from February to May with average wind speeds greater than 10–12 mph (Fig. 1). We have been studying why wind is such a problem with carambola. We are determining the effect of wind speeds and durations on carambola growth, development, water relations, and photosynthesis. Apparently, excessive winds reduce new shoot and leaf growth. Symptoms of wind damage include shoot tip burning, leaf necrosis and deformity, and wind-scarred fruit. Wind appeared to reduce the size of the leaves and thus tree growth.

We protect carambola trees against freezing temperatures with high-volume irrigation. Water protects them in two ways. First by sensible heat, given off as heat (water coming out of the ground in our area is at 68–70°F). Second by heat of fusion as the water freezes. If you can continuously cover your tree with fresh water in an even

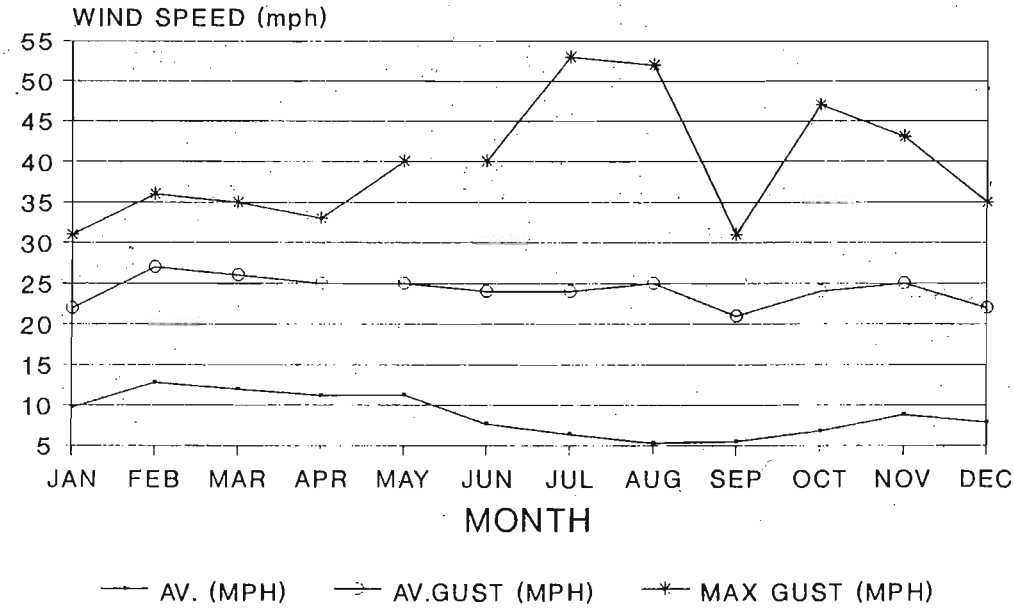


Figure 1. Wind speeds in the Miami area, 1990 (source: National Weather Service).

application, you can encase your tree in ice and keep it at 32°F. You need a reliable irrigation system to get enough water on in a timely manner. Overhead or undertree high-volume systems that deliver at least ¼ in/hr are effective. This technique works with trees that can survive 32°F and that will support the weight of the ice. Sometimes fruits survive this treatment as well.

Atemoya

'Gefner' is our major cultivar. Atemoya is a hybrid of cherimoya and sugar apple, adapted to lowland tropical to cool subtropical climates. Young trees may be killed by temperatures in the range 24 to 27°F and mature trees may be killed at 20°F. We protect atemoya trees from damage by low temperatures with high-volume irrigation. Strong, constant winds can affect the structure and shape of atemoya trees. Most of our atemoya groves are grown in calcareous soil areas. This is a relatively young industry in Florida.

Plant spacings are generally 20 to 25 ft, with a lot of variation among groves (Table 5). Propagation is by grafting on atemoya or sugar apple rootstocks. Atemoya on atemoya is more vigorous, coming into production a little sooner, but it is hard to control its growth. Sugar apple makes a more compact tree. Atemoya trees are propagated by veneer, cleft, and saddle grafting, and sometimes T-budding.

Young trees are fertilized every other month, decreasing to three or four applications per year as trees mature. Micronutrient and foliar applications are similar to other crops discussed. The annona seed borer is our major pest problem. In our area the females oviposit into the seeds when the fruits are between 1 and 6 cm in diameter. We have an emergency exemption to use malathion to control the annona seed borer. This is helpful, if not entirely effective. Our efforts to get labeling approved through the IR-4 Program have encountered a lot of delays. It has been observed that female seed borers can be colonized by a fungus. This may be developed as a biological control. We also have mealy bugs on atemoya. Nitidulid sap beetles are the pollinators, although some people occasionally will hand-pollinate to get an earlier crop and more uniform fruit set. We are investigating ways to manage the beetle populations to get better pollination.

Pruning to remove crossed branches avoids problems with branches breaking due to crop load or accumulation of ice. We did a cooperative trial to try to modify and improve tree structure by encouraging wider crotch angles. Narrow crotch angles have occluded bark, which makes them weaker. Also, newly planted trees are somewhat two-dimensional and fan-shaped. They develop three-dimensionality after they get lateral bud break off the main first shoots; the tissue twists and you get another fan, but in a different direction. We wanted to try to build a three-dimensional tree from the beginning, while also improving crotch angles. One shape we tried was the modified central leader. We cut the leader off to get a lateral to be the new leader. We tried open center, cutting at 4 ft or at 2 ft height. We applied these treatments in March–April, when new growth was coming out. We found that atemoya trees could be trained and manipulated to the modified-central-leader and open-center systems, and branches that developed a wide crotch angle could be easily selected. We hope to begin taking yield data from this trial soon. We may find leaving the tree alone (nonpruned) might be preferable to these pruning methods. Tree training takes about 1½ years of intensive effort. Some topping and hedging is used with atemoya, not only to control tree size but to get off-season bloom or second blooms.

Table 5. Atemoya plant density and spacing and percentage of total acreage at various spacings.

Plant density	Plant spacing (ft)	Trees per acre	Percent of acreage
Moderate	12½ x 20	174	11
Moderate	15 x 20	145	7
Moderate	20 x 20	108	4
Moderate	12½ x 22	158	4
Moderate	15 x 23	126	4
Low	20 x 25	87	38
Low	27 x 28	57	4
High	10 x 20	217	22
Miscellaneous[z]			6

[z]Various plant densities and spacings, each accounting for less than 4 percent of the atemoya acreage.

Source: Crane, J.H. 1989. Acreage and plant densities of commercial carambola, mamey sapote, lychee, longan, sugar apple, atemoya, and passion fruit plantings in south Florida. Proc. Fla. State Hort. Soc. 102:239-242.

Lychee and Longan

'Mauritius' and 'Brewster' are our two main lychee cultivars. We lost about 3/4 of our 'Mauritius' plantings in the hurricane. Plant

Table 6. Lychee plant density and spacing and percentage of total acreage at various spacings.

Plant density	Plant spacing (ft)	Trees per acre	Percent of acreage
Moderate	10 x 25	174	14
Moderate	20 x 20	108	12
Moderate	12½ x 25	139	12
Moderate	15 x 25	116	5
Low	25 x 30	58	14
Low	20 x 25	87	8
Low	25 x 25	69	6
Low	25 x 26	67	6
Miscellaneous[z]			23

[z]Various plant densities and spacings, each accounting for less than 5 percent of the lychee acreage.
Source: Crane, J.H. 1989. Acreage and plant densities of commercial carambola, mamey sapote, lychee, longan, sugar apple, atemoya, and passion fruit plantings in south Florida. Proc. Fla. State Hort. Soc. 102:239-242.

spacing often has been fairly close, the idea being to remove every other tree, which doesn't always happen (Table 6). One grower has a picking device that clips and holds the fruiting panicles, so the fruit does not drop to the ground.

Fertilizer for young lychee is applied monthly for the first 6–12 months, slowing to every 6–8 weeks during years 1 and 2. Applications vary from ¼ to 1½ lb/tree as the trees get larger. Micronutrients go on foliarly three or four times a year, usually in solution with ammonium nitrate. Iron drenches are applied at ¼ to 1 oz/tree two to four times, with younger trees getting the more frequent applications.

The strategy changes as trees begin to produce fruits. In order to bloom and set fruit, lychees require a 3–4-month period of arrested growth induced by water stress, cool temperatures, or a combination. Temperature seems to be the predominant factor in Florida. The vegetative flush must stop growing and harden off. Although growers can't keep it from raining, they do stop irrigating and fertilizing from September to at least December or until they bloom. This is done for longan as well. When the tree blooms, they begin irrigating, and continue to do so during fruit development to avoid drought stress, but they won't start fertilizing until the fruit is set. They will apply fertilizer once or twice during fruit development and again immediately after harvest to help the tree recover nutritionally and promote a good flush that will mature quickly – that takes the cycle up to September again. Fertilizer ratios of 8-3-9 or higher are commonly used.

Growers do not train lychee trees very much, which probably should be done. Splitting occurs during heavy crop years, especially after rains. Corky bark, a proliferation of tissue caused by a moth larvae, does not appear to affect production, but we discourage growers from propagating from trees with this condition. Recently we have had moths attacking the inflorescences, and this has been increasing every year. A bark lice proliferates on the bark and makes the bark appear white, but no damage has been observed. Anthracnose is a problem, especially with 'Mauritius', and nothing is currently registered to control it. A parasitic lichen occurs on leaves when copper is missing from micronutrient sprays.

Longans had a huge crop this year (1992). 'Kohala' is the main cultivar but has an unreliable (irregular) bearing habit. A lot of cultivars have been tested in the past, but most were less reliable than 'Kohala'. There is interest in planting more longan. Our growers usually do not train the trees, although we recommend that they prune to encourage proliferation of terminals. Plant spacings of 20–25 ft are most common. With 'Kohala', we need to thin the panicles to get good fruit size. Some growers trim half or more of the panicle and get a dramatic increase in fruit size and a good price for the larger fruits. So far we have no major pest problems on longan.

COMMODITY TREATMENTS OF TROPICAL FRUITS FOR EXPORT FROM HAWAII

Eric Jang
Tropical Fruit and Vegetable Research Laboratory, Hilo
Agricultural Research Service, United States Department of Agriculture

Introduction

Many of the tropical fruits and vegetables grown in Hawaii are hosts of tephritid fruit flies and are under quarantine regulations to prevent entry of infested material into the mainland U.S. Other quarantine insects such as the annona (seed) weevil and the mango (seed) weevil are also prohibited in the U.S. Today, I would like to review some aspects of postharvest disinfestation and quarantine research being carried out on fruit flies at our laboratory. The laboratory is involved with a wide range of research activities centered on the control of tephritid fruit flies. In addition to the commodity treatment research, the lab is involved in research on biology, ecology, and control of fruit flies and is well known for its programs in fruit fly mass rearing and genetics, biocontrol, and semiochemicals. These various research components are all important in developing technology for possible eradication of fruit flies and for protecting states such as California where, as we speak, attempts are being made to rid an area of introduced fruit flies.

Our commodity treatment group, based primarily in Hilo, is composed of myself, Dr. Harvey Chan, Dr. Jack Armstrong, and Dr. Nic Liquido. Our mission is to develop suitable quarantine procedures for use on fresh fruits and vegetables against fruit flies and other quarantined insects. In addition to developing postharvest disinfestation or commodity treatments to allow export to the U.S. mainland, we provide research information requested by other countries as it relates to our research mission. We have a scientific role in the design and supervision of research. We also help APHIS (USDA Animal and Plant Health Inspection Service) to evaluate the scientific merit of proposals submitted to the U.S by other countries.

Why Quarantines?

Some of you may ask, "Why do we need to have quarantines?" Commodity quarantines arose from the needs of local, state, and federal regulatory agencies to ensure that harmful organisms do not enter areas where they do not already exist. Hawaii is an excellent example. Historically, Hawaii was relatively free from pests, but with the arrival of man we have had many introductions of plants and animals which are now considered pests. Nearly every country in the world now practices some sort of quarantine to prevent introductions of unwanted pests.

Federal quarantine restrictions against tephritid fruit fly pests were established to prevent them from entering the U.S., where they have the potential to cause serious damage to agriculture. California, for example, has a very strict quarantine against entry of products grown in areas where there are fruit fly pests. Many of the major agricultural states also have strict quarantines and well developed programs that monitor quarantine.

Quarantine regulations are mandated under very stringent federal laws which have been passed by Congress over the years. These include the Plant Act of 1912, the federal Plant Pest Act of 1957, and the Noxious Weed Act of 1974. The regulatory responsibility for enforcing federal quarantine restrictions is with USDA-APHIS. APHIS officials inspect U.S.-mainland-bound baggage at the airport here and also participate in inspection programs for commerically grown fruits which are fruit fly hosts. ARS is responsible primarily for basic and applied research towards protecting agriculture and works closely with APHIS. We (ARS) do not regulate anything. We provide research information, much like a university does.

Fruit Flies in Hawaii

Our quarantine problem in Hawaii is largely due to the fact that we have four species of tephritid fruit flies that have been established here. The four economically important species of tephritid fruit flies in Hawaii are the Mediterranean fruit fly (*Ceratitis capitata*), the oriental fruit fly (*Bacterocera dorsalis*), the melon fly (*B. cucurbitae*), and the Malaysian fruit fly (*B. latifrons*); the latter is our most recent introduction to the islands. The Mediterranean fruit fly is probably our most prolifigious one. It attacks more than 250 different species of fruits and vegetables. The melon fly attacks primarily

cucurbits and melons, but can also be found in papayas and some tropical fruits. The oriental fruit fly is the most common pest of tropical fruits for those of you in East Hawaii. The Malaysian fruit fly was first found about five to six years ago in chili peppers in community gardens on Oahu; since then they have been found on all the major islands. Most of these species look very similar, so there is a chance that the Malaysian fruit fly was here well before it was identified.

Fruit flies attack growing fruits on the plant, in contrast to the common vinegar flies, or Drosophila, which attack fruits that have already dropped and have started the decay process. Tephritid fruit flies actively search out the fresh fruit to lay their eggs in; they tend to prefer the riper ones. The gravid female will lay her eggs 2–4 mm into the fruit through her needle-like ovipositor. The eggs hatch into larvae or maggots within one to three days. The larvae burrow into the fruit, feeding on the flesh and causing extensive damage. The mature larvae will then exit the fruit and pupate into the soil a few centimeters below the soil surface. The adult flies emerge from the soil in two to three weeks and start the cycle again.

The primary nesessity of quarantine treatments in Hawaii is to ensure that locally grown commodities do not carry fruit flies. Although the risk can be very small, the consequences can be quite large. Quarantine treatments can be analagous to cancer treatment, where we want to kill the bad cells without damaging the good cells. We are trying to do the same thing with fruit fly larvae. It is difficult to do, because living insect and plant tissues have similar needs, and it is hard to damage one without damaging the other. Thus, a major focus of our work involves basic research in both insect and fruit physiology. Once we have a method we think works, we conduct large-scale efficacy tests involving estimated populations of up to 100,000 insects or more to show that the treatment does in fact kill the insect. Finally, the research data is submitted to APHIS for their evaluation.

Meeting Quarantine Security

There are several ways to approach the task of meeting quarantine security. Some of the methods that have been used include the application of a direct treatment, establishment of fly-free areas, determination of non-host status, and systems approaches.

Direct treatments are treatments applied directly to the fruit in order to kill the insects that may be inside. Example of direct treatments include the use of fumigants, heat and cold, and irradiation. Multiple treatments are situations that occur when a single direct treatment may not be effective, or when one treatment at too high a rate or too long a period of time may damage the fruit. An example of a multiple treatment is to heat the fruit and then cool it down. Those two treatments in combination may give you security without fruit damage.

Establishment of fly-free areas has been used in cases where fruit flies are not normally established and careful monitoring of orchards and packing areas can be carried out. Programs are currently ongoing in Florida and Texas. Establishment of fly-free areas in Hawaii would be difficult due to the large numbers of host materials and the establishment of the flies throughout the islands.

Host status is another way to ensure that fruit may be shipped without a direct treatment. However, in this case you must prove that your commodity is not a host of the fruit fly. Establishment of nonhost status must be documented through years of careful research over many different types of environmental conditions and selection pressures on the insect.

A more recent approach being studied is the systems approach, an integrated pest management approach involving all steps from planting of the tree through orchard management, cultural practices, fly population monitoring, distribution of products into the market place, and so on. The idea is to provide data to show that through proper management, the risk of introducing fruit flies will meet quarantine security (Figure 1.)

Some of the common hosts here in Hawaii for the Mediterranean fruit fly are coffee fruit, citrus, and apple. The oriental fruit fly, being a more tropical species, will be in guava, papaya, mango, starfruit, and many other tropical fruits. A lot of the problems with host status occur because many of the crops you are now considering have not in the past been considered commercial products. There is often little if any data to estabilsh that a given species is a host, but the scientific literature is full of reports of fruit flies infesting tropical fruits. Our lab is continuing to study the host status of tropical fruits and the mechanisms that govern fruit infestation. Fruit ripeness levels can affect infestation levels, for example, with the odor of ripening, ripe, and overripe fruits attracting fruit flies.

Our laboratory has been focusing for the past

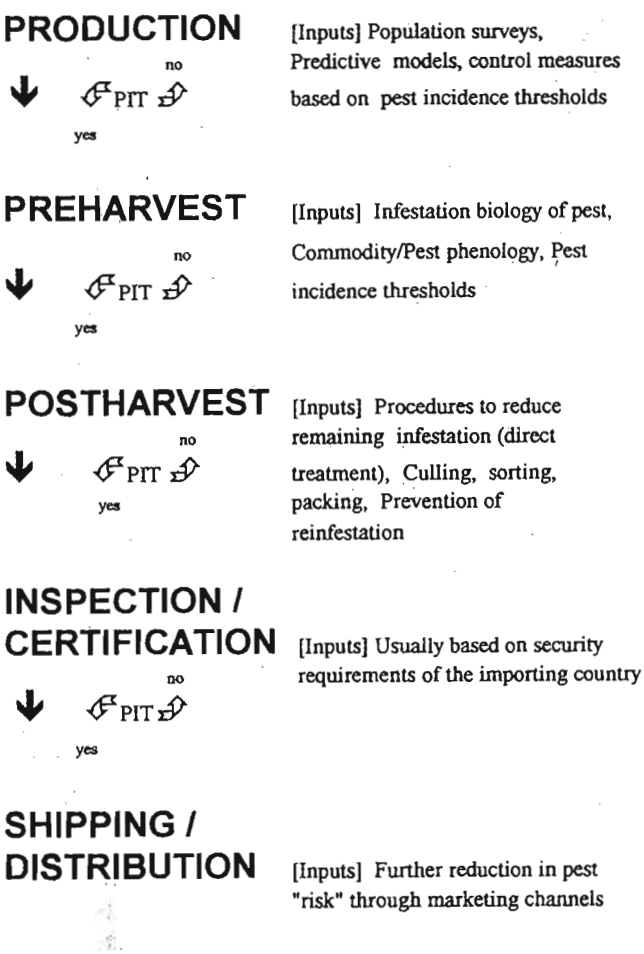


Figure 1. Components of the "systems" approach to acheiving quarantine security. Movement to a subsequent level is dependent on meeting pest incidence thresholds (PITs), or appropriate control measures must be initiated.

several years on physical treatments (heat, cold, and modified atmospheres) to find new ways to kill fruit flies. The loss of ethylene dibromide 10 years ago and the pending loss of methyl bromide as a postharvest fumigant mandates that we research new nonchemical ways to disinfest fruits.

In order to develop a treatment for a given commodity, we need to have available enough quantities of commercially grown fruit to run our tests. We realize that there are large capital costs involved in establishing orchards, but we have to do our work with fruits that you are planning to actually export.

We are currently conducting some tests with carambola and lychee to develop quarantine treatments which would allow you to ship these commodities to the U.S. mainland. Under our laboratory testing conditions, lychee appears to be a poor fruit fly host, but a poor fruit fly host is still a host.

The methods that we use to develop quarantine treatments include infesting fruits with fruit fly eggs and/or larvae, subjecting infested fruits to the proposed treatment, and then comparing the number of survivors in the treatment with nontreated controls. We also evaluate the quality of the treated fruits. Although the process seems simple enough, it is quite labor-intensive and must be done in a specific manner for the data to be accepted. The general process of ARS activity that may lead to APHIS approval is illustrated in Figure 2.

Quarantine treatments developed for fruit flies are routinely subject to a calculated security level know as a Probit-9 security level. This is a statistical treatment of the data which demonstrates 100 percent effectiveness. Data supporting Probit-9 efficacy will support the concept that a given treatment will allow no more than 32 survivors out of a million treated insects, with a 95 percent level of confidence. This is the benchmark test that APHIS requires of fruit fly treatments.

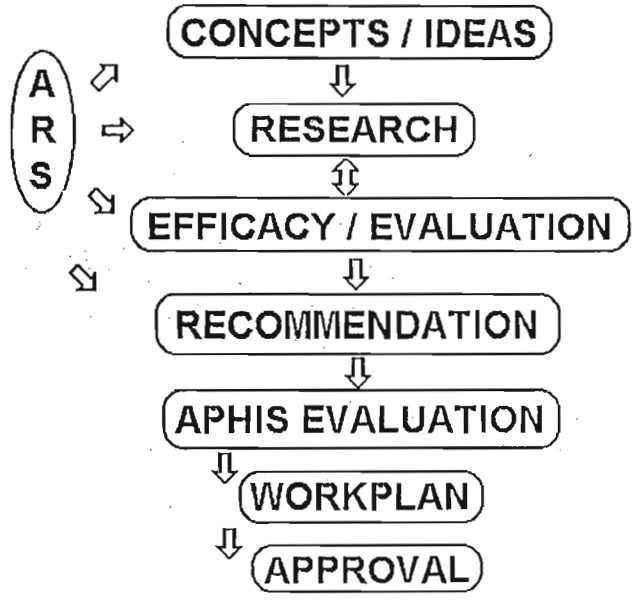


Figure 2. Steps leading to APHIS approval.

HTFG MARKETING PLAN

Gloria K. Wong
Trade Marketing Consultant
Hawaii Department of Business, Economic Development and Tourism

I have been asked to present to you, briefly and clearly, the Hawaii Tropical Fruit Growers Marketing Plan. To do so, I'm going to talk a little on trends, give you a general overview of the Industry, profile the typical consumer, and, of course, describe the vision, mission, and strategy of the Hawaii Tropical Fruit Growers.

Trend Analysis

In the effort of comparative analysis an optimistic benchmark can use the historical trend of the Papaya industry, with the strong aid of the government, as a projecting instrument for the Specialty Tropical Fruit industry. Over a 30-year span, the papaya production in Hawaii has averaged a compounded annual growth rate of about eight percent. More recently, sales to the U.S. mainland and Japan have been increasing at an annual compound rate of about 15 percent.

According to the Industrial Outlook 1991, Department of Commerce, the value of processed fruit is expected to increase at a compound rate of 1.2 to 2.5 percent, frozen fruits to increase 35 percent, frozen citrus fruit to 36 percent, and fruit juices to continue as the leading U.S. export in canned goods.

By comparison, the Hawaii tropical fruit growth rate from 1991 to 1992 was estimated at 71 percent.

Situation Analysis

It is important to understand that the Tropical Specialty Fruit Industry in Hawaii is in the infancy stages of the life cycle. In a real sense, the Hawaii Tropical Fruit Growers Association is taking a lead position in "creating" the industry. The HTFG presents its organization as an aggressive newcomer into a new emerging industry, one that is advancing into a globally competitive marketplace.

It is the long range intent of the organization to move from a production orientation to a marketing orientation and into a global perspective. Most importantly, HTFG recognizes the need to become *consumer*-driven. Because the marketing environment is so dynamic, the position of marketing within the organization is evidently important. The organizational culture may need to change; instead of developing products and then trying to convince consumers to make purchases, the focus will begin with an orientation toward customers' needs and desires.

Peter Drucker, known as the Father of Management, has said that the function of a business is to create a customer, and the two ways of doing that are by innovation and marketing.

The current and near reality also presents itself:

- Hurricane Iniki damage to Mike Strong's farm, which represents a significant percentage of the Hawaii tropical fruit industry, is still under assessment;
- the state of the economy, worldwide and statewide, is weak;
- the lean budgets of the state agencies;
- the buying preferences of the consumer incline toward quick-and-easy and nutritional;
- the new U.S. President, administration, and changing policies.

It all goes to reinforce the fact that the marketplace is dynamic and robust, and the businessperson needs to be aware and ready for challenge.

Hawaii Tropical Fruit Growers
Vision:

Eric Weinert has expressed the vision of making tropical fruit synonymous with a Hawaiian vacation: an essential ingredient to experience Hawaii . . . a grand notion, but one worthy of pursuing.

Mission:

Strategic market planning. Although it is a complex process, in its simplest form it narrows down to identifying who we are, what we do, where we're going, and how we're going to get there. To this cause, the executive committee of HTFG is clarifying its mission as follows:

"HTFG's four goals to its members are to:
1. provide a positive, supportive business

environment;
2) accelerate market penetration of its specialty tropical fruit in Hawaii and the global marketplace;
3) protect, expand and diversify specialty tropical fruit opportunities;
4) develop a cohesive strategic market program that will effectuate a satisfying exchange of value between the consumers and the growers."

More simply said, the goal is to "create demand" such that demand is greater than supply. To do so, it is important to: (1) educate the consumer, and (2) increase awareness of Hawaii tropical fruits. The end result is an increase in market share.

Consumer Profile

The following descriptors are sets of characteristics that describe the typical consumer. It is not a target market, but the information can be used to profile a target market. This information will set the bull's-eye for communicating to the consumer.

According to statistics compiled from the Census Bureau, national surveys, and government agencies, the average American is a white female in her 30s, of European descent, married, has children, and works full time outside the home (Table 1).

According to DBED's 1991 Data Book, "the population of the State is mostly male (51%), relatively young (the median age in 1990 was 32.6 years) and racially diversified."

- The major unmixed groups, based on a 1988 sample survey, were Caucasians (24%) and Japanese (22%);
- in addition, 32 percent were of mixed race, part-Hawaiian;
- in 1990, 7,858 immigrant arrivals, mostly from Philippines;
- 18,999 civilians moved to Hawaii from mainland;
- Japanese and Filipino are the second languages most used at home;
- Roman Catholic;
- Lee, Smith, and Wong are the most common surnames;
- hypertension and impairment of back or spine was the most common health problem;
- average male is 5 ft 7.5 in, 159.5 lbs.;
- average female is 5 ft 2.6 in, 127.9 lbs.;
- 19 percent of adults are functionally illiterate;
- 25 percent of residents completed four or more years of college.

According to the Hawaii Visitors Bureau 1991 Annual Research Report, a visitor profile is described as follows:

- 39.3 yrs. old, male, visiting for pleasure;
- 20 percent travel in a party headed by someone who describes their occupation as a professional;
- close to half travel as couples;
- the majority are repeat visitors;
- the average stay is 8.4 days;
- attracted to the scenery, beaches, water sports, golf, cleanliness, weather, and hospitality;
- westbound visitors stay 9.7 days, predominantly non-group and non-package trip travelers, visits are down 2.9 percent;
- eastbound visitors stay 5.8 days, primarily group and package trip travelers, visits are up 1.7 percent;
- visit only one island, most to Oahu (Maui, Kauai, Big Island);
- from California, E-N Central, or Mountain U.S. regions;
- or, from Japan, Australia, UK foreign regions;
- the U.S. visitor spends $149.54/day, the Japanese visitor spends $344.29/day, other European visitors spend $194/day;
- the spending breakdown is:

	U.S. visitor	Japanese visitor
restaurant	$20.48	$26.90
total F&B	27.85	42.91
entertainment	11.72	17.39
transportation	15.91	15.98
clothing	8.51	31.89
gifts/souvenir	9.37	87.91

Strategy

In February, earlier this year, a congress of experts from the industry, academia, and government met to participate in a "SWOT" analysis: Strengths, Weaknesses, Opportunities, and Threats. The result was a Plan of Action to:

Develop a formal market plan;
Make tropical fruit a part of every Hawaiian vacation, by working with the Hawaii Visitors Bureau;
Develop protocol to ship to and through the mainland U.S.;
Develop a press kit with photographs, descriptions, statistics, and recipes;

Target the food service industry (hotels, restaurants and institutions);
Develop consumer education programs;
Work on common marketing schemes with other commodity groups;
Develop accurate industry statistics.

The direction has been set, the organization is set to moving upon these eight items. Many of you are probably already involved; others may want to contribute to advancing this industry's development.

Invitation to Participate

You have been provided a copy of an interactive worksheet (Appendix 2) to participate in the the Hawaii Tropical Fruit Growers Strategic Marketing Plan Development Program. This interactive method of developing the strategic market plan solicits participation, invitation and sharing of ideas, commitment, understanding of the planning process, and simplicity.

The HTFG Board of Directors invite your participation in the process. It's simple: you circle your choices and turn it in to Linda Huffman or me, today or tomorrow.

Specialty Tropical Fruit's contribution to the economy has been both direct, through the production of crops, creation of jobs, adding to the tax revenue, working an environmentally "green" industry, and indirect, through the enhancement of cultural comfort and the visitor industry. And the outlook is good.

A day without Hawaii fruit is like a day without aloha!

Table 1. The average American (source: *The New York Times*).

Basics:	white, woman	32.7 years old
	married, mother	has some German blood
	high school graduate	family income $35,225/'89
Home:	family owns a home	in the suburbs
	mortgage $737	three bedrooms
	11 to 20 yrs. old	heated with natural gas
Work:	drives to work alone	works for a private co.
	does clerical work	works for a manufacturer
Possesses:	two telephones	no answering machine
	VCR	no guns
	doesn't have a will	3 lbs. garbage/day
	owed $2,317 on credit cards	
Character:	average male, 5 foot 9, 172 lbs.	life expectancy of 71.6 yrs.
	average female, 5 foot 3, 144 lbs.	life expectancy of 78.6 yrs.
	Protestant	belongs to a church
	Democrat	
Health:	5.1 sick days	saw Dr. 5.5 days last yr.
	doesn't smoke	doesn't know anyone w/AIDS
	pays 14% annual spending to medical care	
Activities:	read newspaper daily	1.2 hrs. driving/day
	28 hrs. 13 min. TV/wk	
Eating:	drinks regular soda	drinks low-fat milk
	drinks beer	hates liver
	banana most often bought fruit	
	lettuce most often bought vegetable	

PROGRESS TOWARDS PEST MANAGEMENT IN LITCHI

Vincent P. Jones, Carrie H. M. Tome, and Christopher J. Robb
Department of Entomology, College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

We will describe progress made towards development of an integrated pest management program (IPM) for insect control on litchi. We will briefly discuss what IPM is, then focus on research progress made in the last year.

Pest Management

What is pest management and what sort of information is required? The textbook definition is "the intelligent selection and use of pest control actions that ensure favorable economic, ecological, and sociological consequences." For our purposes, pest management is preventing economic damage to the crop the best way possible considering as many factors as possible. We are not trying to just suppress one insect's population, but look at all the pests' population levels and how they affect the health of the crop. You could conceivably apply pesticides every day and control your pests, but it is economically unfeasible, and ecologically it would destroy all your natural enemies. In addition, your neighbor would probably turn you in to the DOA. We are trying to set up a pest management program that works and is sustainable over time.

There are several pieces of information required for an IPM program. First, what are the pests and natural enemies present in the crop? For fruit crops, when does the female attack the fruit? It doesn't pay to protect your fruit when there are no insects present, or when the fruit isn't susceptible to the insect.

Another important piece of information is the differences in damage between cultivars and locations. This information gives you an indication of what sort of damage levels you can expect under certain situations. Along this same line of thought, we also need to have some measure of the population level of the pest and the natural enemies, so we can look and see if the problem is getting worse or better. You don't want to be applying pesticides if the population is getting better on its own, only when it is getting worse. You also need some sort of information on optimal timing of control measures. We are trying to put on the pesticide only when it is required, and before the population comes out, not after half of it is out and the damage is already done. If you put on the pesticide too late, all you're getting is revenge.

Where is the pest when it is not attacking the fruit? In litchi this is critical because oriental fruit fly is a major problem that we have seen this past year, and it does not complete development in litchi except very infrequently. Many eggs are inserted into the fruit but do not complete development. This means that the population damaging the fruit is coming from outside the orchard. Because of this, it is important to know where the pests are when they are not in your orchard.

You need to know the effect of control measures on the natural enemies as well as on the pests. You don't want to put on a pesticide which controls your main pest but which kills off the natural enemies which suppress other pests. This is the sort of information you need before you can make up a pest management program.

We were contacted by the tree fruit growers to investigate this problem on litchi after the harvest was already done (in 1991), and it was felt the damage was primarily from *Cryptophlebia* species, the litchi fruit moth (*Cryptophlebia ombrodelta*, known as macadamia nut borer in Australia) and the koa seedworm (*Cryptophlebia illepida*). So the objectives of the study were, first, to confirm the identity of *Cryptophlebia* spp attaching litchi and, second, to estimate what percent crop loss there was from this particular insect. We also wanted to determine the period in time that the fruit was susceptible to feeding by *Cryptophlebia* and, lastly, to survey natural enemies and pests which may be upset in the pesticide applications we use.

Pest Biology

Cryptophlebia spp. The two species of *Cryptophlebia* found in the islands have similar life histories. The koa seedworm, *C. illepida*, is endemic to the Hawaiian Islands and was first reported in 1919 on macadamia. It has 18 host plants listed of which macadamia, litchi, and mango are the main economically important hosts. Litchi fruit moth is an accidental import from Australia first reported in 1958, with most of the same host plants. The two species look very similar and have basically the same biology. The physical differ-

ences between them are that the litchi fruit moth is a bit larger and more robust, and there is a small difference in coloration. Both are found in about equal numbers on litchi, while on macadamia we find about 85 percent koa seedworm and 15 percent litchi fruit moth. The larval stage has off-white skin and dark little platelets on the back with hairs coming out, and a black or dark brown head capsule. Damage seen on litchi is frass or fecal pellets sticking out of the fruit that is generally dry, and if you cut open the fruit, you will find damage and larvae inside the fruit.

Oriental fruit fly. Damage to litchi by fruit fly became evident late in the season. The fruit flies seen in the orchard were all *Bactrocera dorsalis* (Hendel), the oriental fruit fly. The damage is caused by the female fly during the act of egg deposition (oviposition). The female fly uses the ovipositor at the tip of her abdomen to insert the eggs through the skin of the fruit. The wound is frequently frothy and causes the skin to turn brown around the hole. In a large proportion of the cases, oriental fruit fly eggs can be seen in the hole or next to it from the outside with a 10x hand lens. When the skin is peeled from the flesh, the inside has a large brown circular mark centered on the oviposition hole. The eggs are often on the surface of the flesh but can also be found inserted several millimeters into the flesh. Eggs are generally deposited in a batch of more than 10 eggs. Fruit deterioration is hastened by bacteria or fungi introduced during the act of egg deposition.

Fruits were held to determine the species of fruit fly and the ability of the fly to complete development in litchi. None of the infested fruits yielded adult fruit flies. Dr. Jack Armstrong at the USDA Tropical Fruit and Vegetable Research Lab, Hilo, indicated to us that only oriental fruit fly has been seen in their studies and that litchi is a very poor host. Fruit flies can complete development in litchi according to his studies, but the survival rate is extremely low. In our collections we found second and early third instar larvae. This suggests that litchi does not harbor resident populations of oriental fruit fly; they must disperse into the orchard from alternate hosts.

Materials and Methods

Study sites were set up at five locations: two in Kona near Captain Cook; one on Oahu near Mililani; and two on Kauai, one near Kapaa and the other near Princeville. At all sites, we placed pheromone traps, containing synthetic sex lures from the females moths, so that we can collect male moths to determine population changes over time. The pheromone traps work for both koa seedworm and litchi fruit moth. These traps were changed at two-week intervals before the end of May 1992, and at approximately one-week intervals after this period until harvest. We have collected fruit from different cultivars when possible at each location each time the pheromone traps were changed. The cultivar types and locations are listed in Table 1.

At each location, we tried to collect a minimum of 75 fruits per cultivar per week. This was done by randomly selecting three or four trees of a given cultivar and selecting 25 fruits per tree. The samples were shipped to Oahu, and fruit size, fruit color, presence of *Cryptophlebia* eggs or larvae, and fruit fly damage was recorded from each fruit. Because it is not possible to distinguish eggs of the two *Cryptophlebia* species, egg deposition is recorded only as *Cryptophlebia* spp rather than as each species separately. Over all five sites and four cultivars, more than 8,000 fruits were examined for this study. Damage is reported as all samples and the last two weeks before harvest. The all-sample estimates may be misleading at certain sites because the data were not taken for all cultivars over the entire season. The last two weeks prior to harvest are a good indicator of what the grower finds at harvest time.

Results

***Cryptophlebia* spp identity.** The litchi fruit moth and the koa seedworm have both been collected at all sites in the pheromone traps. In Kona, the litchi fruit moth population density was approximately 60 percent lower than the koa seedworm density throughout the study period. On Kauai, the trends were reversed, with litchi fruit moth population levels being higher. On Oahu, the population levels of both moths are extremely low compared to both Kona and Kauai.

Cultivar differences. The percentage of fruits found with *Cryptophlebia* eggs varied markedly within a location and between cultivars (Table 2). At the first site on Kauai, there were marked differences between the percentage of fruits with *Cryptophlebia* eggs present. The cultivar 'Kwai May-Pink' had the highest percentage of fruits with eggs, followed by 'Kaimana', 'Kwai Mi', and 'Groff'. The 'Kway May-Pink' sampled at this location were in a different block than the other three cultivars and to some extent the differences in levels may reflect a higher population density in that particular block. However, high egg deposi-

Table 1. Orchard locations and cultivars sampled.

Location	Kwai Mi [x]	Kwai May-Pink [y]	Kaimana	Groff	Orchard description
Kauai 1 Princeville	X	X	X	X	Young trees, mixed cultivars, part of a large tropical fruit orchard, irrigated, border trapping for oriental fruit fly, weeds under fair control most of season
Kauai 2 Kapaa	X	–	–	–	Mature (~12 m high) trees, surrounded by native and introduced vegetation, not irrigated, occasional border trap for oriental fruit fly, grass orchard floor, few weeds
Kona 1 Captain Cook	–	X	X	–	Young trees, mixed cultivars, part of large tropical fruit orchard, surrounded by vegetable growers, mac nuts and coffee in the vicinity, irrigated, border trapping for oriental fruit fly, weeds under good control
Kona 2 Captain Cook	–	–	X	–	Young trees, interplanted with coffee, not irrigated, no border trapping, few weeds
Oahu Mililani	X	–	–	X	Mature orchard, not irrigated, no border trapping, grass orchard floor, no weeds

[x] = 'Tai so'. [y] = 'Bosworth 3'.

tion was also observed on 'Kwai May-Pink' at the first Kona site, suggesting that this is a cultivar-specific trait. Egg deposition at the second Kauai site on 'Kwai Mi' and the first Kona site on 'Kaimana' were also high, while that observed on 'Kaimana' at the second Kona site and 'Kwai Mi' and 'Groff' at the Oahu site were quite low.

Damage from *Cryptophlebia* did not necessarily follow the egg-laying pattern (Table 3). In particular, there was a high proportion of fruits with eggs at the second Kauai site and at the first Kona site, but damage on the 'Kwai Mi' and 'Kaimana' varieties was less then 2.5 percent and on the 'Kwai May-Pink' approximately 6.67 percent. This points out that there is a tremendous amount of *Cryptophlebia* egg mortality occurring on litchi and mere presence of eggs is not a good indicator of damage with will be observed. Instead, the number of eggs laid is a better indicator of potential damage if all conditions are favorable for *Cryptophlebia* population growth.

Time of fruit susceptibility. Adult female *Cryptophlebia* moths have been shown to lay eggs primarily on macadamia nuts that are greater than 20 mm in diameter. We found that also occurs on litchi (Fig. 1). On the cultivar 'Kwai Mi', 5 percent of the eggs were laid on fruit that were less than or equal to 20 mm in diameter. Also, the size-egg deposition relationship remained fairly constant between the different sites (Fig. 1). When looking at the cultivars 'Kwai May-Pink' and 'Kaimana', it appeared that the moths were laying a greater percentage of eggs on progressively smaller fruits, but even so, at 20 mm, only 8.8 and 3.8 percent of the fruit had *Cryptophlebia* eggs present (not enough eggs were laid on the cultivar 'Groff' at either site to determine the relationship for that cultivar accurately). From these data, protection of the fruit before they are 20 mm long appears to have little benefit regardless of the cultivar grown.

'Groff' litchi appears to be relatively nonsusceptible to koa seedworm (Tables 2 and 3). This may be related to the relatively small fruit size of this cultivar (peak average size ~ 26 mm)

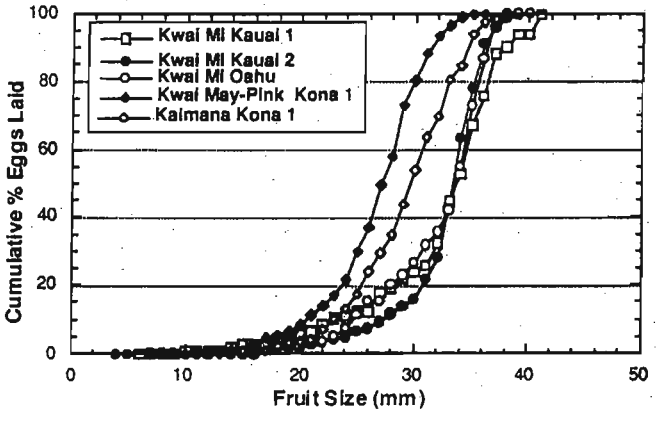


Figure 1. ***Cryptophlebia*** **oviposition on various fruit sizes on three cultivars at three sites.**

Table 2. Percentages of litchi fruits with eggs from *Cryptophlebia* spp at five locations.

Location	Cultivar: Kwai Mi [x]	Kwai May-Pink [y]	Kaimana	Groff
Kauai 1				
All samples	10.51	55.38	9.56	1.74
Last 2 wks	15.35	52.00	14.65	1.98
Kauai 2				
All samples	29.55	–	–	–
Last 2 wks	49.83	–	–	–
Kona 1				
All samples	–	26.69	54.22	–
Last 2 wks	–	44.67	55.75	–
Kona 2				
All samples	–	–	3.36	–
Last 2 wks	–	–	1.98	–
Oahu				
All samples	7.07 [z]	–	–	4.25 [z]
Last 2 wks	11.44 [z]	–	–	2.20 [z]

[x]='Tai so'. [y]='Bosworth 3'. [z]This orchard was not followed to full maturity of 'Groff' at the grower's request; 'Kwai Mi' reached full maturity, but required another week's sample to be comparable to other orchards.

Table 3. Percentages of litchi fruits damaged by *Cryptophlebia* spp at five locations.

Location	Cultivar: Kwai Mi [x]	Kwai May-Pink [y]	Kaimana	Groff
Kauai 1				
All samples	0.13	16.59	0.94	0.00
Last 2 wks	0.00	29.00	3.00	0.00
Kauai 2				
All samples	1.03	–	–	–
Last 2 wks	1.15	–	–	–
Kona 1				
All samples	–	3.01	1.69	–
Last 2 wks	–	6.67	2.30	–
Kona 2				
All samples	–	–	0.14	–
Last 2 wks	–	–	0.65	–
Oahu				
All samples	0.30[z]	–	–	0.13[z]
Last 2 wks	1.50[z]	–	–	0.44[z]

[x]='Tai so'. [y]='Bosworth 3'. [z]This orchard was not followed to full maturity of 'Groff' at the grower's request; 'Kwai Mi' reached full maturity, but required another week's sample to be comparable to other orchards.

and the relatively short period between the time when it achieves 20 mm in length and harvest begins. At the location on Kauai, the average fruit length was over 20 mm for approximately 21 days, but harvest was occurring during the last two weeks of this period. Studies performed in temperature cabinets have shown that ~ 8 days is required for egg hatch at 20°C. Therefore, the window in time during which the female moth lays eggs and harvest is quite narrow. For damage to occur on this cultivar in significant amounts before harvest, females would have to be at high population levels just when the litchi are slightly less than 20 mm in diameter. Prompt harvest assures that damage will not be excessive.

The cultivars 'Kwai May-Pink' and 'Kwai Mi' both exhibited rapid fruit growth and an extended period where they were over 20 mm long. At the Kona site, the 'Kwai May-Pink' was greater than 20 mm in diameter for a period of 55 days, and at the Kauai locations for 49 and 50 days. The 'Kaimana' litchi at Kona was greater than 20 mm for at least 46 days, and on Kauai for at least 44 days. The longer period in time between 20 mm in length and harvest makes a close synchrony between the moth populations and fruit size less important, and consequently the potential damage from *Cryptophlebia* on these cultivars is greater.

Oriental fruit fly. Regardless of its ability to complete development in litchi, the dispersal of oriental fruit fly into the orchard and subsequent fruit damage is an extreme problem for litchi growers (Table 4). Damage levels were high on all the cultivars (at least at one of the sites) except for 'Groff'. The most extensive damage was found on the cultivars 'Kwai Mi' (~ 31 percent damage) and 'Kaimana' (~ 28 percent damage) at the second Kauai site and the first Kona site, respectively.

There is considerable variation in damage within a single cultivar between sites. This probably reflects the fact that because litchi is a poor host to build up oriental fruit fly populations, most of the damage must come from flies which migrate into the orchard from surrounding vegetation. It is particularly interesting to note that the 'Kaimana' cultivar at the two Kona orchards were less than 1,000 yards away from each other, yet the damage levels were ~ 28 percent and 0.4 percent, respectively. The orchard with the lower damage level had coffee interplanted with litchi and was

Table 4. Percentages of litchi fruits damaged by oriental fruit fly at five locations.

Cultivar: Location	Kwai Mi [x]	Kwai May-Pink [y]	Kaimana	Groff	
Kauai 1					
All samples	2.88	10.75	8.75	0.74	
Last 2 wks	3.96	8.00	15.50	1.49	
Kauai 2					
All samples	28.40	–	–	–	
Last 2 wks	30.68	–	–	–	
Kona 1					
All samples	–	1.91	16.61	–	
Last 2 wks	–	2.00	28.16	–	
Kona 2					
All samples	–	–	0.31	–	
Last 2 wks	–	–	0.40	–	
Oahu					
All samples	5.51[z]	-	-	0.00	z
Last 2 wks	11.44[z]	-	-	0.00	z

[x]='Tai so'. [y]='Bosworth 3'. [z]This orchard was not followed to full maturity of 'Groff' at the grower's request; 'Kwai Mi' reached full maturity, but required another week's sample to be comparable to other orchards. A pesticide was applied just as fruits began to color.

not irrigated, while the other field was a mixed-cultivar block in the center of a large tropical fruit orchard. The other interesting comparison is the high damage level on 'Kwai Mi' at the second Kauai site compared to the other two locations.

Time of susceptibility to oriental fruit fly. As with other crops (such as papaya), the period of fruit fly susceptibility is closely tied to the state of fruit maturity. Because we recorded the color of each fruit as green, 1/3 red, 2/3 red or full red, we were able to determine at which stage most oriental fruit fly damage occurred. The general trend for all cultivars was that within a site, damage at the green stage was fairly low to nonexistent compared to 2/3 red or full red (Fig. 2). The 'Kwai May-Pink' cultivar showed an unusual amount of damage on the 1/3 red stage, but this may be related to the difficulty in judging the more yellowish color of this cultivar.

Damage at different heights from *Cryptophlebia* spp and oriental fruit fly. At the second Kauai site, we were able to take some samples from high in the canopy and compare the damage to that observed in the lower part of the canopy. For both species, the damage was significantly

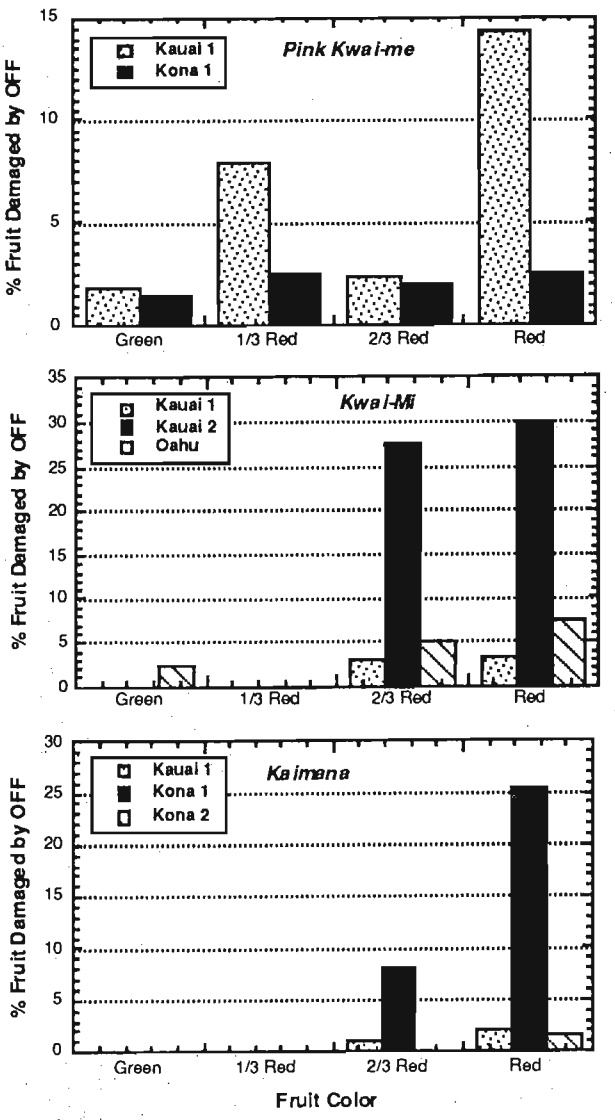


Figure 2. Percentage of fruit damage by oriental fruit fly on three cultivars at four ripeness stages.

higher at the lower elevation (~ 2 meters) vs. the higher elevation (~ 7 meters) (Fig. 3). This means that the success of a management program could be determined from samples on the lower branches without fear that the top of the tree is suffering high damage levels.

Does oriental fruit fly only attack fruit damaged by *Cryptophlebia* spp? One of the questions asked was, Do fruit flies only attack fruits already damaged by litchi fruit moth? The answer to this is clearly no. Damage on a number of the cultivars is much higher from oriental fruit fly than it is from litchi fruit moth. At two of the

sites, one in Kona and one in Kauai, there was enough litchi fruit moth and oriental fruit fly damage that we were able to do statistical tests of the association, and the two types of damage were completely independent.

Other insects and mites found on litchi. There is a wide variety of insects found associated with litchi. Their economic importance varies depending on cultivar, location, orchard cultural practices, and treatment history. This makes predicting the pest status or the effect of pesticide applications on nontarget species associated with the crop difficult and imprecise at best.

Of the 18 species observed, four are serious pests which must be dealt with on a regular basis, three or four have questionable pest status, six are natural enemies of pest species, and three are pollinators (Table 5). To reduce damage from this complex requires a management plan which reduces the pest species but does not eliminate the natural enemies or the pollinator species.

There are several pests other than *Cryptophlebia* and oriental fruit fly which are important. The most widespread pest is the erinose mite, which occurs on the leaves. We found this everywhere we worked on litchi. If left to itself, high population levels can develop and leaves are severely deformed.

Spider mites were another problem, particularly in the drier parts of the islands. They caused a significant amount of leaf bronzing, but nobody seemed to care that much; we didn't see any leaf drop; the population seemed to drop off in the warm part of the summer. They are something surely to be concerned about in the future. The predator mites are another thing we have to be concerned with in the sense that they prey on the spider mites and the erinose mites, and if we contemplate using pesticides on litchi we have to make sure that the predator mites are not destroyed, or you are going to have perennial spider mite and erinose mite problems.

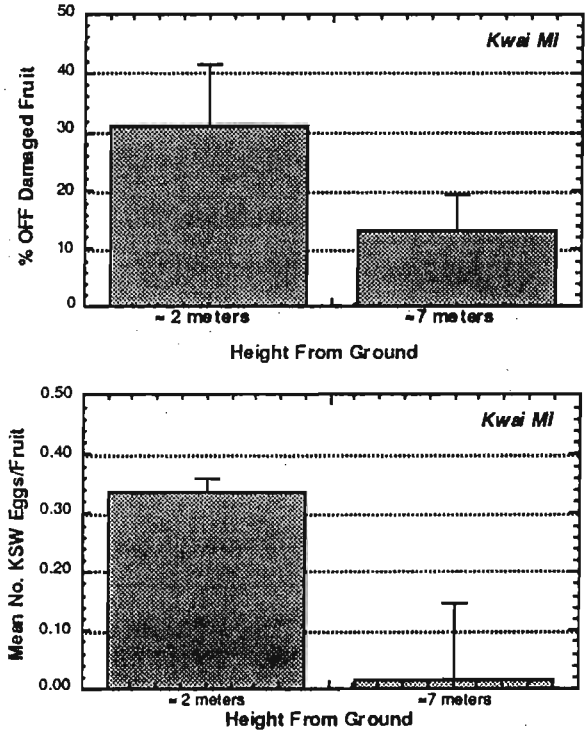


Figure 3. Effect of height from ground on fruit damage by oriental fruit fly (OFF) and koa seedworm (KSW) on litchi cultivar 'Kwai Mi'.

Management

Cryptophlebia spp. Populations of these two moths can be monitored using pheromone traps which can be obtained from several commercial sources. Trece, Inc. (408-758-0205, Salinas, CA) is the direct supplier. The traps required are the pherocon 1CP and the lures are for the oriental fruit moth. Locally, Brewer Environmental Industries, Inc., may be able to special-order the traps and lures. Lures should be replaced at three-week intervals and the bottoms of the traps when they get dirty. The number of moths found in the traps should be recorded at approximately weekly intervals to determine if populations are increasing rapidly at a time when the fruit are susceptible (0.7" in diameter or 18 mm diameter).

Registration of carbaryl is being completed for control of *Cryptophlebia*. Carbaryl is used in Australia for control of *Cryptophlebia* and is quite efficacious. Based on our studies, *Cryptophlebia* do not attack fruit less than about 18 mm in diameter (0.7"). Sprays should not be applied before this time regardless of the population density recorded in pheromone traps. The cultivars 'Kwai Mi' and 'Groff' probably do not have to be treated, but 'Kwai May-Pink' will probably require treatment to prevent damage. 'Kaimana' may also need to be protected, depending on the population level in the orchard and the surrounding host plants.

The use of mating disruption has been tried on *Cryptophlebia* spp on macadamia in Hawaii. Mating confusion involves using the synthetic sex lure used in pheromone traps to saturate the entire orchard. This is thought to reduce mating because it is difficult for males to find female moths. The trials on macadamia were not a success; although egg deposition was reduced by

Table 5. Insects and mites found or reported on litchi in Hawaii.

Common name	Scientific name	Order: Family	Plant part	Notes
Pests found on litchi in our study				
Erinose mite	*Eriophyes litchii*	Acari: Eriophyidae	leaves	severe/mild damage
Koa seedworm	*Cryptophlebia illepida*	Lepidoptera: Tortricidae	fruit	severe on certain cultivars
Litchi fruit moth	*Cryptophlebia ombrodelta*	Lepidoptera: Tortricidae	fruit	severe on certain cultivars
Oriental fruit fly	*Bactrocera dorsalis*	Diptera: Tephritidae	fruit	severe on most cultivars
Branch & twig borer	*Xylothrips religiosa*	Coleoptera: Bostrichidae	branches	attacks branches
Mango flower beetle	*Protaetia fusca*	Coleoptera: Scarabidae	fruit	?[z]
Green scale	*Coccus virdis*	Homoptera: Coccidae	leaves, wood, occasionally fruit	
Spider mite	*Oligonychus spp*	Acari: Tetranychidae	leaves	mod./high levels leaf bronzing, all locations
Green lacewing	*Chrysoperla carnae*	Neuroptera: Chrysopidae	all	predator of soft-bodied insects
Big-headed ant	*Pheidole megacephala*	Hymenoptera: Formicidae	all	predator/tends soft scales
leafhopper	*Sophonia rufiofasciata*	Homoptera:	leaves	no evidence of damage
Phytoseiid mite	*Phytoseius hawaiiensis*	Acari: Phytoseiidae	all	predators associated with Erinose mite, spider mites, small soft-bodied insects
Phytoseiid mite	*Euseius nr. ovalis*	Acari: Phytoseiidae	all	same as above
Phytoseiid mite	*Euseius nr. vivax*	Acari: Phytoseiidae	all	same as above
Phytoseiid mite	*Amblyseius largoensis*	Acari: Phytoseiidae	all	same as above
Blow flies	–	Diptera: Calliphoridae	flowers	pollinator ?
Honey bee	*Apis mellifera*	Hymenoptera: Apidae	flowers	pollinator
Flower fly	–	Diptera: Syrphidae	flowers	pollinator
Pests reported in other areas and present in Hawaii but not seen during our study				
Chinese rose beetle	*Adoretus sinicus*	Coleoptera: Scarabidae	leaf	severe on young trees only
Mediterrean fruit fly	*Ceratitus capitata*	Diptera: Tephritidae	fruit	poor host for medfly, no problem here (except quarantine)
Southern green stinkbug	*Nezara viridula*	Hemiptera: Pentatomidae	fruit	may aggravate early fruit abortion, damage older fruit
Pacific fruit piercing moth	*Othreis fullonia*	Lepidoptera: Noctuidae	fruit	difficult to control because of stong dispersal and feeding habits

[z]reported damaging fruit, but mouthparts are degenerate; no mention in the literature about damage.

50 percent, significant damage still occurred. Work on this in the future will probably intensify, and improved application technology may make this a viable option in the future.

Oriental fruit fly. Oriental fruit fly does not complete development to any significant degree in the litchi orchard. They migrate in from the outside and deposit eggs into the fruit, eggs which rarely complete development. However, the act of puncturing the fruit to lay the egg results in an oozing wound and the introduction of microorganisms into the fruit, rendering it unsaleable. Strategies for managing the insect therefore require that the fly is prevented from moving into the orchard. Because only female flies damage the fruit, all control measures should be aimed at the females.

Traps for monitoring oriental fruit fly should be aimed at the females. Current trappings using methyl eugenol as an attractant are useless for pest management. First, they trap only males, and second, as stated above, they may have an attractive radius of greater than one mile. Considering that most of the tropical fruit orchards are rather small, and that if the traps are placed near the edges, many of the flies trapped are not from your orchard, but instead come from the surrounding region. For pest management, you want a trap with a limited radius of attraction so that you can see what's happening in your orchard. If you want to know population levels outside the orchard, place a trap outside the orchard. Traps which should work for fruit fly attraction are yellow panels coated with tanglefoot (an adhesive) and having an ammonia lure (available commercially from several manufacturers). Alternatively, yellow balls approximately 8.5 cm in diameter coated with tanglefoot should provide information on the changes in population levels if trap catch is recorded weekly. Traps should be replaced when dirty or when the lure expires.

Carbaryl, which is being registered for *Crypto-*

phlebia spp on litchi, is not effective against oriental fruit fly; therefore, the registration of malathion and a partially hydrolyzed yeast protein bait (Nulure) should be pursued. This combination is generally considered to be the most effective control measure for fruit flies, because the female flies require the protein source for egg production. The malathion generally has a preharvest interval of less than three days. For example, Clean Crop Malathion 8 Aquamul has a preharvest interval of two days on mango, passion fruit and guava, but on citrus it is seven days. The downside of this pesticide is that the residue is short-lived, lasting less than seven days under even the best conditions. However, its low mammalian toxicity means that it would probably be easier to register than other materials. It would be wise to register this material on any tropical specialty fruit that will be sold fresh-market. If it is easier to register malathion without Nulure, this should be pursued.

Because of the long period that some of the litchi cultivars are susceptible, a material with a longer residue should be investigated. However, a systemic material is not desirable, because the flies do not complete development in the fruit anyway. A contact insecticide is required. Candidate materials all require the approval of the manufacturer for registration. Before any material is used on a widespread basis, its effects on natural enemies must be tested to prevent what is known as "the pesticide treadmill." The pesticide treadmill is when natural enemies for secondary pests are eliminated by pesticide treatments for a particular pest and then treatment for the other pests is required because their natural enemies are gone. This leads to more and more pesticide use. We currently have few pesticides registered, but all new materials should be introduced with caution.

Other possibilities include any pesticide with a repellent action. This would be particularly effective in litchi because the oriental fruit fly population is primarily moving in from outside the orchard. A neem product (Azatin) is discussed below and may be good for fruit fly control.

Bait buckets used by some growers only capture adult males. Because males do not damage the crop, this is a "revenge" tactic which costs money but does nothing to reduce damage. The idea behind the bait buckets is that by trapping out all the males in an area, females will not be able to mate and lay fertile eggs. In litchi, however, the females are migrating in from outside the orchard and have a flight range of greater than one mile. All females may not be mated upon entering the orchard, but it is almost certain that a large proportion are. In studies on other crops where oriental fruit fly can complete development, it is clear that greater than 99 percent of the males in the area must be trapped out before any reduction in fruit infestation levels are found. This sort of tactic must be applied to a *large* area. Studies by the USDA fruit fly laboratory have shown that in a 63-hectare papaya field a very high density of bait buckets (or other dispensers) was not able to reduce damage levels.

Malathion can now be used on the windbreak trees to reduce immigration into the orchard (see the Hawaii Tree Fruit Journal No. 2 for information). In high population levels, this may not be very effective, but in areas with low population levels, spraying the windbreak trees with malathion and Nulure (protein bait) will provide some relief for growers.

When a pesticide is registered for fruit fly control, it should not be applied until the fruits begin to color. While fruits were green, we almost never saw any damage. The 'Kwai May-Pink' cultivar, which is somewhat yellowish, should be watched closely because it is hard to determine exactly when it begins to change.

Litchi erinose mite. This mite is easily controlled by sulfur, but sulfur is not registered on litchi. Studies in Australia have shown that erinose mite moves between trees by traveling on honeybees (and probably large flies, etc.). Erinose mite can probably be controlled using Safer Insecticidal Soap, if the coverage is good. Coverage is extremely important, because Safer has no appreciable residue and kills entirely by contact. A benefit of using Safer is that it is generally not toxic to predaceous mites which help keep erinose mite populations regulated.

Future candidate pesticides. The industry should pursue the registration of materials which may control pests not currently found within the state. A good candidate is Azatin, which is an extract of the neem tree, *Azadirachta indica*. This product now has a very favorable registration category which allows registration with very minimal testing; the industry must request it, and phytotoxicity tests must be run according to the manufacturer. Azatin has activity against whiteflies, thrips, and lepidopterous larvae. It also acts as a repellent in some trials and may therefore be a good candidate for helping reduce oriental fruit fly damage. As with any pesticide, the effects on natural enemies must be examined.

POSTHARVEST HANDLING OF HAWAII'S NEW TROPICAL FRUIT CROPS

Robert E. Paull
Department of Plant Molecular Physiology
College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

In the past ten years, we have been looking at various aspects of the postharvest handling and physiology of tropical fruits. With the exception of banana, these fruits have received little attention when compared to temperate fruits such as apples and subtropical fruits such as citrus and avocado. This research has been limited by funds and fruit availability. Projects have been carried out on lizhi, soursop, and, of course, papaya and pineapples.

Funding provided by the Governor's Agricultural Coordinating Committee through the Hawaii Tropical Fruit Growers Association has allowed us to expand our research and focus on handling procedures associated with insect disinfestation treatments. I would like to report some of our early results with carambola, rambutan, and lizhi, with a passing mention of atemoya. Some of these results are preliminary but very encouraging for lizhi and carambola.

Carambola

There is no comparative information on the ripening changes that occur in the carambola varieties now grown in Hawaii. The changes affect fruit quality and are a basis for determining maturity grade standards. There was no significant difference between full-colored 'Arkin', 'Kajang', 'Sri Kembangan' and 'Kary' with respect to wing-to-body ratio and flesh firmness (Table 1). Total soluble solids, a measure of sugars, were higher in 'Kajang', with 'Kary' having the lowest value. However, the lower acid content of 'Kajang' and 'Sri Kembangan' gives these two varieties and 'Kary' higher sugar-to-acid ratios (Table 1). The high sugar-to-acid ratio for 'Kajang' was due to an increase in sugars and a decline in acids during ripening. All varieties showed this decline in acids during ripening, with the greatest decline occurring in 'Kajang' and 'Sri Kembangan'. This data will be useful for developing grade standards.

Fruit waxing (FMC-960, 1:1 wax:water) had little effect on water loss in fruits stored at 1°C (34°F) for up to three weeks (Table 2). Fruit coloring, skin appearance, wing tip appearance, and days from harvest to full color were unaffected by waxing. Waxing reduces weight loss, but the choice of wax type is very important (Table 2). Some waxes delay fruit ripening and slightly reduce the loss of fruit body and wing tip appearance. Heat treatment makes wax choice more difficult, as it changes the relative order of the effectiveness of different waxes (Table 2). Waxing enhanced the loss of appearance of fruits treated with hot water (49°C, 20 min) or forced air (to 47.5°C fruit core temperature), especially in fruits that were full color when treated, less so for fruits treated when they had just started to show color.

Table 1. Physical and chemical characteristics of different carambola varieties grown in Hawaii at two different stages of fruit ripeness.

	Quarter ripe				Full ripe			
Variety	Wing/body ratio	Firmness (kg)	TSS[x] (%)	Acids (meq/100ml)	TSS/ Ac[x]	TSS[x] (%)	Acids (meq/100 ml)	TSS/ Ac[x]
Arkin	0.34 a[z]	2.7 ab	6.7 ab	5.3 a	1.28	7.2 b	4.9 a	1.49
Kajang	0.33 a	2.2 b	6.8 ab	5.1 a	1.32	8.0 a	3.9 b	2.30
Sri Kembangan	0.33 a	2.1 b	7.3 a	5.2 a	1.35	7.4 b	3.9 b	1.55
Kary	0.32 a	3.3 a	7.0 a	5.2 a	1.35	6.8 c	4.6 a	1.91

[x]TSS = Total soluble solids; TSS/Ac = ratio of TSS to acids.

[z]Numbers in the same column followed by the same letter are not significantly different ($P < 0.05$).

Table 2. Effect of different waxes and heat treatment on weight loss, days to full color, fruit and wing tip appearance. Higher fruit appearance scores indicate poorer fruit appearance (maximum score = 6). The variety was Sri Kembangan, and the fruit had 70 percent skin color at the time of treatment.

Treatment	Weight loss (%)	Days to full color	Fruit appearance	Wing tip appearance
No Heat	2.2 c[z]	6.2 c	1.5 c	1.2 b
FMC-705 (1:1)	2.4 c	7.1 b	1.7 c	1.0 b
FMC-960 (1:1)	1.8 cd	6.6 bc	1.3 c	1.0 b
Decco 231 (1:1)	1.3 d	6.7 bc	1.5 c	1.1 b
Semperfresh M (2%)	1.3 d	7.2 b	1.4 c	1.2 b
Forced Air 47.5°C	5.2 a	6.6 bc	4.1 a	5.5 a
FMC-705 (1:1)	2.6 c	7.8 a	3.6 ab	5.6 a
FMC-960 (1:1)	2.6 c	8.0 a	3.8 a	5.2 a
Decco 231 (1:1)	3.2 b	6.9 b	3.3 b	5.2 a
Semperfresh M (2%)	3.9 b	6.3 c	3.3 b	5.2 a

[z]Numbers in the same column followed by the same letter are not significantly different ($P < 0.05$).

Forced-air treatment of carambola has possibility for insect quarantine. The relative humidity during treatment is crucial to reducing loss of fruit appearance. Higher relative humidities, greater than 95 percent, significantly helped retain fruit appearance (Table 3).

Under certain circumstances, it may be necessary to accelerate fruit ripening. Ethylene gas treatment is used for all commercial banana and we have tested its possible use on carambola. Ethylene treatment reduced the days to full color, though weight loss was greater in ethylene-treated fruits. Heat treatment of fruits followed by ethylene treatment had no effect on days to full color or fruit appearance.

Rambutan

Increasing treatment temperatures and exposure times increased weight loss and loss of hair and skin appearance (Table 4). Lower temperatures gave less damage. It took approximately 20 minutes for the fruit core temperature to reach 47.5°C. Higher relative humidities during treatment reduced water loss and fruit external appearance (Table 5). However, the overall appearance was still judged to be unsatisfactory. Fruit storage at 12.5°C (54.5°F) following forced hot air treatment developed white mold on the skin; this did not occur on control fruits. Overwrapping the punnetts with Cryovac D955 shrink wrap before treatment did reduce the injury further and may offer another avenue for further research. Hot-water dip caused more damage than forced hot air. Waxing with four different waxes had no effect in reducing skin injury. Waxing before heat treatment may offer some possibilities for improvement in appearance retention.

Lizhi

During the last season, we focused on three aspects of lizhi postharvest handling: (1) punnetts, overwraps, and waxes; (2) heat treatments and sulfur dioxide; and (3) cold treatments. The data on cold treatments are still being analyzed, but it is clear that if water loss is controlled, skin browning is not a problem in cold-stored fruit (1°C).

Of concern is the marketing of lizhi; punnetts offer greater convenience and have market appeal. The question is, How many holes should a punnett have in the top or bottom, or whether an overwrap is better at retaining fruit appearance? Skin browning and weight loss were similar for punnetts that had holes in the top and/or bottom and those held in a closed plastic bag (Table 6). The skin browning and weight loss were greater in the punnetts with any combination of holes than in a solid punnett with an overwrap of stretch film or shrink wrap. Overwraps of perforated film with

Table 3. Effect of relative humidity during forced-hot-air treatment of 'Sri Kembangan' on appearance five days after treatment. Higher fruit appearance score indicates poorer fruit condition (maximum score = 6).

Treat.	Relative humidity (%)	Weight loss (%)	Fruit appearance	Skin color (%)
None		1.33 c[z]	1.3 c	97 a
47.5°C	50	2.87 a	3.1 a	89 b
	65	2.10 b	2.8 a	91 ab
	80	1.22 c	2.3 b	92 ab
	95	1.45 bc	2.2 b	92 ab

[z]Numbers in the same column followed by the same letter are not significantly different (P<0.05).

Table 4. Time-temperature response of rambutan to heat treatments (Forced hot air, 50–60% RH). A higher appearance score indicates a poorer fruit condition (maximum score = 6).

Treat.	Time (min)	Weight loss (%)	Appearance Hair	Appearance Skin
None		5.1 d[z]	1.3 d	0.4 c
47.5°C	15	4.4 e	2.0 c	0.7 c
	30	4.9 d	2.6 c	1.5 b
	60	7.4 b	3.5 b	1.7 ab
	90	8.1 a	3.6 b	1.7 ab
50°C	15	4.9 d	3.3 bc	1.7 ab
	30	5.5 cd	3.6 b	1.8 a
	60	6.4 c	3.9 a	2.2 a
	90	8.7 a	4.4 a	1.8 a

[z]Numbers in the same column followed by the same letter are not significantly different (P<0.05).

Table 5. Effect of relative humidity during forced-air treatment (47.5°C) of rambutan on weight loss after one day and skin and hair appearance after five days. Higher fruit appearance scores indicate poorer fruit appearance (maximum score = 6).

Relative humidity (%)	Weight loss (%)	Appearance Hair	Appearance Skin
50	4.5 a[z]	6.0 a	4.9 a
65	2.7 b	6.0 a	5.0 a
80	2.1 c	5.9 a	4.3 b
90	1.2 d	4.6 b	4.2 b

[z]Numbers in the same column followed by the same letter are not significantly different (P<0.05).

Table 6. Effect of various waxes, wraps and punnetts on weight loss and fruit color of lizhi six days after treatment and exposure to room temperature (22°C).

Treatment		Weight loss (%)	Fruit color
Punnett	No holes	4.6 b[z]	2.5 b
	Holes only on top	6.2 a	3.0 b
	Holes top, bottom	6.6 a	3.2 ab
D955 Shrink wrap on punnett		0.6 e	2.0 c
Stretch wrap on punnett		1.9 d	2.0 c
SM250 wrap on punnett		3.5 c	3.8 a

[z]Numbers in the same column followed by the same letter are not significantly different (P<0.05).

two different perforations gave no better protection than a punnett with four holes in the top and bottom. However, decay could be a problem in overwrapped punnetts, though it was not a problem in these tests.

Wrapping punnetts required more handling, and waxing the fruit may be an alternative. A number of commercial waxes were compared with the newer USDA–Florida wax. Waxing does reduce water loss, with the reduction in skin browning being very dependent upon the wax used. One of the more traditional waxes, FMC-560, is better than the light or heavy formulations of the Florida wax. The best treatment was still punnetts that were wrapped with Cryovac D955.

Hawaii's lizhi have a major hurdle to overcome in order to export to the mainland – insect disinfestation. Two insect disinfestation treatments are being considered: heat and cold. Both treatments cause severe stress, and heat causes almost immediate skin browning (Figure 1). The planned treatment of 49°C for 20 minutes

causes obvious loss of skin color. The quest is to retain the skin color; this seems possible using a modification of the sulfur dioxide treatment now used in Israel for lizhi and Thailand for longan. The sulfur dioxide is being used as a bleaching agent and is, I believe, still allowed for food processing. The problem would be very different if we used it as a fungicide. Sulfur dioxide is used for table grapes as a fungicide. Sulfur dioxide can be supplied from bottled gas, burning sulfur, and the much less desirable sodium bisulfite dip.

The protocol that is being considered is sulfur dioxide to bleach the lizhi skin to a yellow-white, followed by the insect disinfestation hot-water treatment, cooling, and then regaining the skin color with a brief acid dip (Figure 2). The color that returns is pinker than in untreated fruits, with the intensity increasing with the time (Table 7).

Table 7. Use of sulfur dioxide to prevent skin browning due to hot-water disinfestation treatment. Higher fruit appearance scores indicate poorer fruit appearance (maximum score = 6).

Treatment	Weight loss (%)	Appearance
No treatment	3.8b [z]	2.5 a
Hot water (20 min, 49°C)	2.7 c	3.0 a
Sulfur dioxide and acid	4.0 b	2.0 b
Sulfur dioxide-hot water-acid	4.7 a	1.9 b

[z]Numbers in the same column followed by the same letter are not significantly different ($P<0.05$).

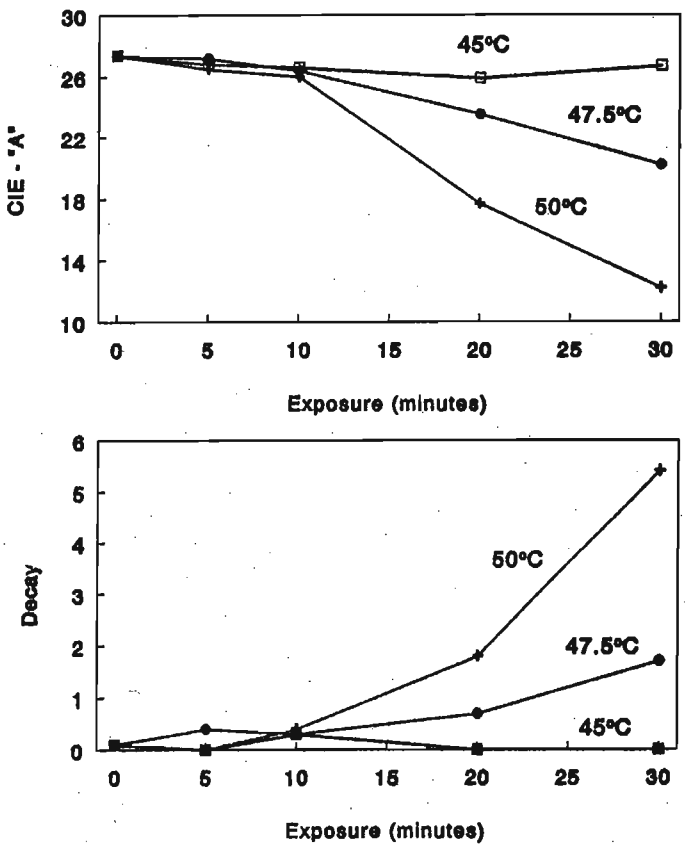


Figure 1. Effect of different time-temperature exposures on loss of lizhi red skin color and fruit decay.

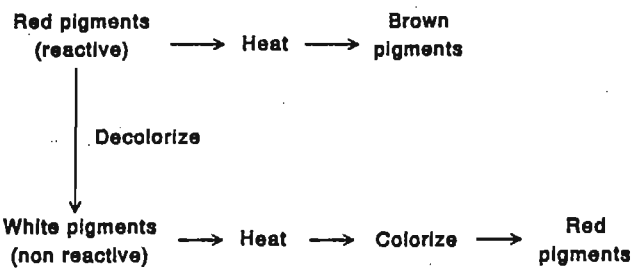


Figure 2. Protocol to avoid heat-induced lizhi skin browning using sulfur dioxide decolorization compared to normal skin browning process.

Weight loss in sulfur dioxide treated fruits is higher, so we will have to integrate a wax or overwrap the punnett. Initial taste tests suggest that if the sulfur dioxide dose is controlled, no difference can be detected. The beauty of this treatment is that the fruits do not turn brown after treatment.

Atemoya

Worldwide, fruit splitting during ripening is a major problem. This splitting is related to water redistribution within the fruit as the starch is converted to sugar during ripening. In attempts to reduce this problem and extend shelf life, we have shrink-wrapped fruits with Cryovac D-955; this did not fully prevent splitting, but it did give some extension of postharvest life (Table 8). Other treatments including waxes and packing did not help to reduce fruit splitting, though there were differential effects on weight loss.

Table 8. Effect of different waxes and wraps on fruit ripening of atemoya cv. 'African Pride'. A higher score for skin blackening indicates greater darkening (maximum score = 6).

Treat.	Weight loss (%)	Days to full ripe	No. of splits	Skin blackening
None	9.1 a[z]	7.3 b	6.4 c	2.8 b
FCC 960 (1:2)	7.9 b	7.8 ab	8.3 a	3.6 a
Saran wrap	4.2 d	9.6 a	5.6 c	3.6 a
D955 wrap	1.3 f	9.2 a	4.2 d	2.8 b
Decco 231 (1:2)	8.6 a	7.8 ab	8.0 ab	3.4 a
Styrene box, wet paper	3.1 e	8.1 a	7.6 b	3.4 a
FCC 560 (1:2)	6.8 c	6.8 b	9.0 a	3.3 a

[z]Numbers in the same column followed by the same letter are not significantly different (P<0.05).

Table 9. Effect of relative humidity during forced-hot-air treatment on atemoya fruit ripening. A higher score for skin blackening indicates greater darkening (maximum score = 6).

Treat.	RH (%)	Weight loss (%)	Days to full ripe	Number of splits	Skin black-ening
None		7.1 c[z]	4.1 c	2.9 c	2.6 c
Heat (47.5°C)	50	14.2 a	8.0 a	3.9 b	5.0 a
	65	13.5 a	7.6 a	3.3 c	5.3 a
	80	12.2 b	6.4 b	5.9 a	4.3 b
	95	13.1 ab	6.5 b	4.5 b	5.1 a

[z]Numbers in the same column followed by the same letter are not significantly different (P<0.05).

Heat treatments did not reduce splitting, though shrink-wrapping before heat treatment reduced the number of splits and delayed ripening. Fruits heated to a fruit core temperature of 47.5°C (RH 90%) had very significant water loss (11.6%) and maximum skin blackening (Table 9). Heat treatments may offer possibility for quarantine; however, the skin-blackening problem needs to be addressed. Relative humidity during heat treatment had no effect on the degree of skin blackening five days after treatment. Higher relative humidity during heat treatment did reduced the number of days to the full-ripe stage when compared to fruit treated at 50 percent relative humidity.

Summary

Carambola

Able to set preliminary grade standards.

Heat treatment with high humidity is a possible disinfestation alternative.

Waxes have a role in reducing injury due to water loss.

Rambutan

Weight loss is a major problem: no solutions; high relative humidity during treatment is some help; not able to prevent fruit from turning black.

Lizhi

Waxing not much help in preventing browning during insect disinfestation heat treatments.

A wrap is best on punnetts; no holes in punnett an alternative, though not as satisfactory.

Sulfur dioxide excellent at preserving skin color during heat treatment.

Atemoya

Shrink wrap has possibilities for such a high-value crop; no solution to splitting, though shrink wrap helps.

This first season's results have eliminated a number of treatments that do not assist in quarantine treatment quality maintenance. In collaboration with industry representatives, we are planning a schedule of experiments for next season.

LISA FOR HAWAII PROJECT

Bart Jones
Hawaii Farm Bureau Federation

On July 1, 1991, the LISA for Hawaii's Diversified Crops Project began implementing its goal to measure and demonstrate alternative agriculture. This two-year project received state funds due to letters of support from your association and other farmer organizations. I manage the LISA for Hawaii Project for the Hawaii Farm Bureau Federation (HFBF). The Governor's Agriculture Coordinating Committee is responsible for the contract with and distribution of funds to the Hawaii Farm Bureau Federation.

We are 17 months into the two-year contract, and our action as catalyst, supporting change in Hawaii's farm systems, is well under way. The title Low Input Sustainable Agriculture (LISA) derives from a successful USDA research program, and a large part of the LISA for Hawaii Project is modeled in its image. "Low input" refers to the use of less off-farm materials of any kind. Green manures and nitrogen fixing plants replacing synthetic chemical fertilizers are examples. Low input is also trap crops and habitat management systems. These practices increase populations of natural pest parasites and predators while reducing pesticide requirements. "Sustainable agriculture" utilizes farm systems that endure and regenerate a healthy farm ecology. These systems are based on improving the soil and natural resources necessary for farm production.

Hawaii's tropical fruit producers encounter all the pressures validating the necessity for economically sound LISA information. Few if any pesticides are registered for use on tropical fruit crops. The limited size of your industry keeps chemical companies from investing the vast sums of money necessary to clear any future chemicals. Environmental scrutiny of nonpoint-source pollution places new responsibility on farmers using chemical inputs. Urban neighbors grow more critical of agricultural chemicals. The good news is the new market opening up for organic and pesticide-free products.

The LISA for Hawaii Project is designed to explore solutions to these problems and show Hawaii farms overcoming them. A four-part approach is taken by the LISA for Hawaii Project:

(1) "Formulate and initiate actions necessary to attract a commercial insectary to Hawaii." A growing mainland LISA trend uses beneficial insects in augmentation programs. Beneficial insects purchased from insectaries are released in fields to supplement or replace pesticide control. Hawaii's farmers have little or no access to these insects, and it is illegal to import them from out-of-state.

(2) "Compile a list of Hawaii's organic farming labeling problems and solutions for presentation to the National Organic Standards Board (NOSB)." Many Hawaii farmers consider selling produce under the coming federal "organic" label. The LISA for Hawaii Project's organic standards lecture series resulted in a letter to the NOSB regarding unique tropical solutions for inclusion in the federal organic statute. One of our recommendations, not previously considered by the NOSB, is the addition of cinder as an approved material.

(3) "Disseminate project results through field days, data bases and publications." The LISA for Hawaii Project's quarterly newsletter started this phase at the beginning of the year. A video is due out in January 1993, and information on completed LISA studies will be available after June 1993.

(4) "Select and fund LISA projects, monitor their implementation, and extend resulting information." This unique component brings research funds to farmers and scientists interested in quantifying the value of a LISA practice.

The research and demonstration part of the LISA for Hawaii Project received an outstanding response from the community. Fifty research proposals arrived from farmers and scientists, along with numerous requests for field day demonstration grants. Ten on-farm field demonstrations of LISA practices and research were selected. The field days provide opportunities to see results and speak first-hand with farmers using this technology. They are scheduled around the Big Island, Maui, and Kauai throughout 1992 and the first half of 1993. Farms using green manures,

alley cropping, and dryland permaculture practices will be open to the public. Other demonstrations range from sheep controlling weeds in avocado orchards to a 20-acre, commercial organic papaya farm.

Numerous research projects apply to the tropical fruit industry. "Sod Management on Sustainable Orchards" (part of tomorrow's field day) measures the results of chemically fertilizing grass alleys of a starfruit orchard and depositing clippings under the trees for converted slow nutrient release. This takes place in a high-rainfall area with porous soils where chemical fertilizers quickly leach out. An alley cropping experiment is measuring the values of nitrogen fixing in an orchard of breadfruit and macadamia. A compost project is underway that controls insect pests in cull macadamia nuts. Results from this work could lead to tropical fruit crops using composting to manage some of their pest problems.

Necessity is the mother of all invention. Hawaii's agriculture needs information on lowering our use of expensive chemicals, improving our soils for lasting results, and alternatives to pesticides no longer available. Hawaii Tropical Fruit Growers is a new organization of farmers growing commercial crops new to Hawaii. Your industry's commitment to innovation and challenge is well established, and low input sustainable agriculture will benefit from the solutions you discover.

PERMACULTURE IN A SUSTAINABLE FUTURE

John Pollack

I'd like to deal with permaculture as a growing ethic in our society and in doing so would read to you the definition of permaculture from Bill Mollison's book which is that:

> Permaculture is the conscious design and maintenance of agricultural ecosystems that have the diversity, stability, and resilience of natural ecosystems. It is the harmonious integration of landscape and people, providing their food, energy, shelter, and other material and most natural needs in a sustainable way.

This has often reminded me of the Hawaii state motto, which is that "The life of the land is perpetuated in righteousness." This seems to express, in seed form, Mollison's concept of permaculture, and although there may be some ambivalence as to what constitutes righteous behavior, there are probably a few things we could all agree upon as far as concern for the land goes.

1. The nurturing of soils is high on the list of priorities, as all life is sustained by a thin and fragile crust of soil. If we work toward systems which emphasize feeding and building soils as opposed to those which tend to degrade and erode, we stand a substantially better chance of creating a healthier future.

2. Custodial attitudes, I believe, go hand in hand with nurturing of soils. The simple act of working with the soil dulls the demands of ownership and allows a certain connectedness to take place that lends itself to the caretaker's mentality.

In cultivating one's ability to observe what the environment has to offer and how natural systems cooperate, we can then make well advised decisions as to our role in upholding and complimenting these systems.

Indigenous peoples throughout the world have been able to sustain themselves and their cultures for thousands of years without benefit of modern agricultural practices, and this is because they possess not a sense of seniority over their environment but a heartfelt reverence for it.

3. Preservation of biodiversity becomes a natural offshoot to a custodial attitude.

Current trends show greater rates of extinction in both plant and animal kingdoms, and what is disturbing about this is that these are generally not a result of natural disaster but are largely man-made, resulting from a cut-and-run attitude which sells short our ability to deal with natural systems in more benign and benevolent ways. It seems that if we are to find our place in the overall scheme of things, it would behoove us to cultivate an attitude of respect and acceptance for all living things.

This is not to say that the pests that eat our vegies and bore holes in our fruit trees should be welcomed with open arms, but that methods of IPM and crop diversity can greatly enhance our ability to create pesticide-free zones and thereby allow once again for the strengthening of natural systems.

4. The judicious use of waste materials is part of the weave of a sustainable lifestyle, as it defines ways in which used-up "stuff" can be recycled and put to use again and again.

Also within our own environment the judicious use of household wastes, grey water, animal manures, and plant biomass can enhance sustainability greatly.

For me, understanding the need for soil preservation, biodiversity, and a custodial attitude has resulted in an ethic which is geared toward creating ever greater degrees of sustainability so that our needs are increasingly met and in fact surpassed by the way in which we interact with the environment.

This ethical interaction results in an ability to make decisions which impact in positive ways the health of natural systems. These powers of observation also prevent a great deal of destructive behavior that can take place, not necessarily with any malice aforethought, but nevertheless can result from doing things too precipitously.

What also results is that we choose more and more to devote time to freeing ourselves from institutionalized power structures such as government and big business.

In devoting more time to sustainable pursuits we can effectively lower our land taxes, water rates, water usage, gas and electrical consumption, as well as food and clothing costs. At the same time the benefits of growing one's own fruits, vegetables, eggs, milk and meat is simply built into the process.

Taking advantage of alternative energy systems also results in less reliance on those institutions that govern power output. Ultimately the abundance found in one's own environment is seen more and more to contain all the necessary components of a sustainable lifestyle.

Sustainability spreads as a result of individual efforts which yield local changes, i.e., that more food becomes available to local markets. New foods are introduced, energy production by way of biogas digestion can provide the alternative powers of fuel and fertilizer, and as networks of like-minded people continue to grow, small co-op marketing structures will form to facilitate an expanding market for goods and services. What follows is the growth of local economies.

This build-up of real and natural connections becomes more effective in time, and thus the priority of sustainability maintains strength.

Permaculture's place in a sustainable future becomes more apparent when we see what these individual and groups efforts can accomplish. This in turn provides the opportunity for individual effort, no matter how small, by giving relevant information based on experience to those who seek greater self-reliance; and whether someone is putting planter boxes on their condo lanai for vegetables and herbs or farming a 10-acre polyculture, what results is that more information and techniques are made available to the general public concerning ways in which we can take more control of our lives while acting in accord with the ethical mandates of earth care.

As a result of networking, R & D projects can and usually do arise resulting in refinements as well as a focus for local and regional workshops.

These can include the kinds of courses that Michael Howden and I have been involved with as well as courses which can be integrated into school curriculums.

In conclusion, I'd like to say that with individual efforts, no matter how small or limited, the idea of sustainability and the ethical mandates of permaculture become more conscious parts of a person's life and in so doing enable us to change our priorities.

These changes may occur slowly or rapidly but what results is that permaculture's prime directive, which is that "The only ethical decision is to take responsibility for our own existence and that of our children," gains increasing credibility and strength.

In this regard, what Mike and I and others have been doing on Maui and what many people have been doing here is, I believe, by way of demonstrating what can be done, in small and somewhat isolated ways at present but hopefully in larger, more expanding and more connected ways in the future.

"MOW AND BLOW" FIELD DAY AT PLANT IT HAWAII

Joe DeFrank
Department of Horticulture
College of Tropical Agriculture and Human Resources
University of Hawaii at Manoa

The Project

The objective of this research project conducted in a three-year-old starfruit (carambola) orchard was to compare two methods of orchard fertilization for their effects on tree growth, leaf nutrient levels, and weed control. The two systems compared were "mow and blow" and "conventional." In the conventional system a set regime of chemical fertilizers is applied within the canopy drip zone around each starfruit tree. The trees grow in a weed-free strip maintained with applications of the systemic herbicide glyphosate (Roundup^{R}). In the nonconventional mow and blow system, the fertilizers are delivered to the ground cover growing in the between-row space. Nutrient-rich ground cover clippings are subsequently cut and placed as a mulch in the weed-free strip under the starfruit rows. The mulch serves two functions: (1) slow release of nutrients through leaching and decomposition, and (2) suppression of weed growth. Fertilizer application and mowing were done at 60–90 day intervals. The experiment will be continued for two years.

Preliminary Results

The greatest biomass was obtained in fertilized areas where vasey grass (*Paspalum urvillei*) was the predominate species. An unexpected result occurred when fertilizers were applied to the ground cover area: an estimated 75–85 percent of the leguminous ground cover species (*Desmodium heterophylum*) died. This species never returned to the fertilized areas.

The large amount of biomass produced and applied as mulch was successful in reducing most of the weed species growing from seeds. However, a grass component (California grass, *Braciaria mutica*) in the mulch became established in the crop row due to rooting of its stem cuttings. The rooted California grass did not pose too severe a problem, because the systemic herbicide glyphosate was used to remove weeds in all treatments to maintain a commercial level of control. By the end of the first year, the remaining species in the ground cover area appeared to be losing vigor and thinning.

The response of the starfruit trees to the two orchard management systems has yet to be determined. Growth will be measured by the increase in trunk circumference after the first and second year of imposing both management systems. An additional measurement of tree nutrient status involves an analysis of the foliage at the beginning of the experiment and again one and two years later. One-year trunk circumference measurements and leaf samples were taken in May 1993.

Summary

The fertilization and removal of clippings from naturalized grasses and legumes will eventually cause a shift in ground cover species composition. In this case, in Mountain View, Hawaii, the legume species was eliminated. Regrowth of perennial grasses that can root from stem cuttings can be a problem when they are applied as a thick mulch. Cutting operations that fracture the clippings and prevent rooting would be an improvement to this management approach. The loss in ground cover vigor and density after one year of fertilization and mulch removal indicates that selection and development of ground cover species specifically adapted to this system of management needs to be done. Improvements to this approach of orchard management would include combined mowing, mulch recovery and placement equipment designed specifically for a mow and blow system, use of selected orchard ground cover species that produce large amounts of biomass without rooting when applied as a mulch, and fertilizer placement both directly around the trees and into the ground cover area for mulch production.

APPENDIX 1.

(818) 363-3680
DAVID and TINA

8 A.M. - 5 P.M. DAILY BY APPOINTMENT
PLEASE CALL BEFORE COMING

PAPAYA TREE NURSERY RETAIL PLANT LIST - 1991-92

(Located in the San Fernando Valley - Map on Reverse Side)

Hello! We established PAPAYA TREE NURSERY to provide clients with a source of over 65 species of high quality, rare and exotic fruit trees. We produce the majority of our nursery stock, which is grafted to cultivars adapted to Southern California growing conditions. We invite you to tour our ten year old test orchard and see trees like mango, papaya, allspice, bananas, guava, cherimoya, sapote, etc., and sample those fruits in season. Also, we provide advice on tree selection, site location, fertilization, and watering.

CODE: (S) - Grown From Seed
(V) - Vegetatively Propagated; e.g., cuttings, grafts, marcots or tissue culture

EXOTIC FRUIT TREES (Alphabetical)

(V) _____ ACEROLA/BARBADOS CHERRY, *Malpighia glabra* (Manoa sweet) - Barbados
(V) _____ ASIAN PEAR/ , *Pyrus serotina* (Shinseiki, 20th Century, Shenko) - China
(V) _____ BANANA, *Musa spp.* (Apple, Ice Cream, dwf. Jamaican red, dwf. Brazilian, Raja puri, dwf. orinoco) - Asia
(V) _____ BLUEBERRIES, *Vaccinium ashei* (Becky, Chaucer, Sharpblue, Avon) - USA
(V,S) _____ BLACK SAPOTE/SAPOTE PRIETO, *Diosporos ebenaster* (Emerich) - Mexico
(V,S) _____ CAPE GOOSEBERRY/POHA, *Physalis peruviana* - Peru
(V) _____ CAPULIN TROPICAL CHERRY, *Prinus salicifolia* (Lomeli, Huache grande) - Mexico
(V) _____ CHEH/CHINESE MULBERRY, *Cudrania tricuspidata* (male/female) - N. China
(V) _____ CHERIMOYA, *Anona cherimoya* (M&N, Booth, White) - S. America
(S) _____ CHERRY OF RIO GRANDE, *Eugenia aggregata* - Brazil
(V,S) _____ EGGFRUIT/CANISTEL, *Pouteria campechiana* (Bruce) - S. America
(V) _____ FEIJOA/PINEAPPLE GUAVA, *Feijoa sellowiania* (Nazemetz) - Brazil
(V) _____ FIG, *Ficus carica* (Excell, Panache, King, Verdal Launge) - Asia Minor
(S) _____ GUAVA-STRAWBERRY, *Psidium littorale var. longpipes* - Brazil
(S) _____ GUAVA-LEMON, *Psidium littorale var. lucidium* - Brazil
(V) _____ GUAVA-TROPICAL, *Psidium guajava* (Turnbull white, Frankel, Indian red) - S. America
(V) _____ GRUMICHAMA, *Eugenia brasiliensis* - Brazil
(S) _____ ICE CREAM BEAN/PACAI, *Inga feuillei* - S. America
(S) _____ JABOTICABA, *Myrciaria cauliflora* - Brazil
(V) _____ JABOTICABA-YELLOW, *Myrciaria glomirata* - Brazil
(V) _____ JUJUBE/BER/ *Zyzyphus jujuba* (Li) - Asia Minor
(V) _____ KIWI VINE, *Actinidia chinensis* (Abbott, Vincent) - China
(V) _____ KEI APPLE, *Dovyalis caffra* (Arcadian, lg. sweet cultivar) - Africa
(V) _____ LITCHEE, *Litchi chinensis* (Brewster) - China
(V) _____ LOQUAT/ , *Eriobotria japonica* (Big jim) - China
(V) _____ LONGAN/ , *Euphoria longana* (Kohala) - S.E. Asia
(V) _____ LUCUMA, *Pouteria obovata* (Rosalia, Montero) - Chile
(V) _____ MACADAMIA NUT, *Macadamia integrefolia/tetraphylla* (Cate, Beaumont) - Australia
(V,S) _____ MALABAR CHESTNUT, *Bombax glabra* - S. America
(V) _____ MANGO, *Mangifera indica* (Keitt, Thomson, Reliable, others) - India
(V) _____ MULBERRY-PERSIAN/ , *Morus nigra* (Kaester) - Persia
(V) _____ PAPAYA-BABACO, *Carica pentagona* - Ecuador
(V) _____ PAPAYA-TROPICAL, *Carica papaya* (Dwarf malaysian) - S. America
(V) _____ PASSIONFRUIT-PURPLE, *Passiflora edulis* - Brazil
(V) _____ PEPINO DULCE, *Solanum muricatum* (Temptation) - Ecuador
(V) _____ PERSIMMON-FUYU/ , *Diosporos kaki* - China
(V) _____ PISTACIO, *Pistacio vera* (Sfax, Rashti, Gazvin) - Persia
(S) _____ PITOMBA, *Eugenia luschnathiana* - Brazil
(V) _____ PITAHAYA/NIGHT BLOOMING CEREUS, *Hilocereus undatus* (with pollenator) - Mexico
(V) _____ PINEAPPLE, *Ananas comosus* (White sugarloaf, Taihitian, Spanish red) - S. America
(V) _____ POMEGRANATE/GRANADA, *Punica granatum* (Fleishman sweet) - Persia
(S) _____ ROSEAPPLE/POTAU, *Syzygium jambos* - Malaysia

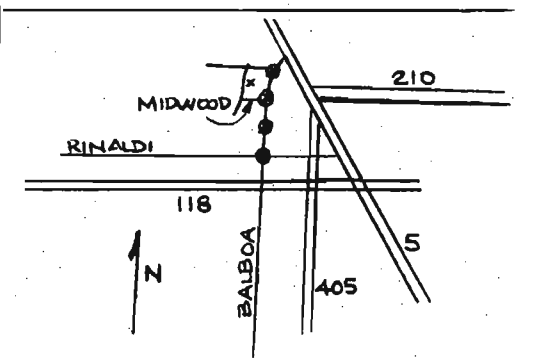
(V)_____ SAPODILLA/CHICO, *Manilkara zapota* (Ponderosa, Alano, Silas) - S. America
(V)_____ STARFRUIT/BILIMBI/, *Averrhoa carambola* (Florita, Arkin, Fwangtung, Sri Kembangan) - India
(V)_____ SURINAM CHERRY/PITANGA, *Eugenia uniflora* (Lolita, Vermillion) - Brazil
(V)_____ TREE TOMATOE, *Cyphomandra betacea* (Red, Yellow) - Peru
(S,V)_____ WAMPI/ , *Clausena lansium* (Sweet cultivars) - China
(V)_____ WHITE SAPOTE, *Casimiroa edulis* (Suebelle, littlepote) - Mexico
(V)_____ YELLOW (WOLLY LEAF) SAPOTE/MATASANO, *Casimiroa tetrameria* (Max golden) - C. America

EXOTIC HERBS AND SPICES

(V,S)_____ ALLSPICE/PIMENTA, *Pimenta dioica* - Carribean Is.
(S)_____ CAPERBUSH/ALCAPARRA, *Capparis spinosa* - S. Europe
(S)_____ CURRYLEAF/ , *Murraya koegnii* - India
(S)_____ COFFEE, *Caffea arabica* - Africa
(S,V)_____ MIRACLEFRUIT, *Synsepalum dulcificum* - Africa

RARE APPLE TREES (maximum height 7 feet)
Specially selected Low Chill Types for Southern California

(V)_____ Anna, Dorsett golden, Ormsby, Makepeace, Joelette, Redgold



BACKYARD NURSERY-PULL IN DRIVEWAY
12422 EL ORO WAY
-BALBOA OFFRAMP, NORTH
-MIDWOOD WEST (LEFT)
-NORTH ON EL ORO WAY

NEW AND UNUSUAL CITRUS

(V)_____ SWEET LEMON/, *Citrus limoneta* - Persia
(V)_____ MEIWA KUMQUAT/ , *Fortunella crassifolia* - China
(V)_____ ORO BLANCO GRAPEFRUIT, *Citrus papadisi x C. grandis* - S.E. Asia
(V)_____ PUMMELO/ , *Citrus grandis* (Chandler) - S.E. Asia
(V)_____ KAFFIR LIME/ , *Citrus hystrix* - S.E. Asia
(V)_____ BLOOD ORANGE, *Citrus chinensis* (Moro, Sanguinelli) - S. Europe
(V)_____ CALAMONDINE, *Citrus madurensis* - Phillipines

FRAGRANT, FLOWERING PLANTS

(V)_____ JASMINE INDIAN/SAMPAQUITA, *Jasminium sambac* (Grande duke, Maid of N. Orleans)
(V)_____ PLUMERIA, *Plumeria acuminata, P. rubra*
(V)_____ CHAMPACA/BAI LAN, *Michelia alba, M. champaca*

PAPAYA TREE NURSERY
12422 El Oro Way
Granada Hills, CA 91344

[Inclusion of this list provided by Mr. David Silber does not constitute an endorsement by the Hawaii Tropical Fruit Growers, the College of Tropical Agriculture and Human Resources, the University of Hawaii, or their employees.]

APPENDIX 2.

Name_____ Organization_____

HAWAII TROPICAL FRUIT GROWERS
Strategic Marketing Plan Development Program
An Interactive Worksheet

This worksheet is being provided to the participants of the Second Annual International Tropical Fruit Conference. This interactive method of developing the strategic market plan solicits participation, invitation and sharing of ideas, commitment, understanding of the market planning process, and simplicity.

The results of this program will be submitted to the Hawaii Tropical Fruit Growers Board of Directors for the purpose of focusing its Strategic Market Plan. Although the Plan will elaborate from the Mission Statement to Goals and Objectives, Strategy, and Action Plan, you are being asked to respond only to the Mission Statement and Goals.

DIRECTIVE: Review the sections and their brief definitions. From your work perspective and experience, choose an option that you think best describes HTFG; circle that choice. You may comment when an option might better fit another section or if you'd like to add another option choice.

SECTION 1. MISSION STATEMENT:

A long term vision of what an organization seeks to do and what kind of organization it intends to become. "This is our business and what it will be".

CHOOSE ONE:

Option 1. The fundamental purpose of the Hawaii Tropical Fruit Growers Association is to provide products and services of such quality that our CUSTOMERS will receive recognized value and our MEMBERS will share in a sustained, preferred return on their investment.

Option 2. HTFG Association's basic business mission is to become a leader in the specialty tropical fruit industry. The Association uses 3 approaches in pursuit of this mission: (1) to introduce specialty tropical fruit to the marketplace as a nutritional and pleasant food treat; (2) to position the specialty tropical fruit in association with a Hawaii vacation; (3) to educate the consumer of the versatility of presenting specialty tropical fruit.

Option 3. HTFG's four goals to its members are to: 1) provide a positive, supportive business environment; 2) accelerate market penetration of its specialty tropical fruit in Hawaii and the global marketplace; 3) protect, expand and diversify specialty tropical fruit opportunities; 4) develop a cohesive strategic market program that will effectuate a satisfying exchange of value between the consumers and the growers.

Option 4. I don't see any value to developing a strategic plan, and I don't care to participate. [If you choose this option, stop now and return this worksheet.]

SECTION 2. GOALS:
A conceptual target that HTFG intends to pursue to accomplish its mission. "This is where we're going".

CHOOSE the most important THREE or FOUR. Add or Clarify wording as you think appropriate.

Option 1. Conform the orientation of the HTFG into a marketing concept and work with a current marketing plan.

Option 2. Increase dialogue and cooperative participation between the private and public sectors, including the Hawaii Visitors Bureau, to achieve clear mutual goals.

Option 3. Develop a protocol to allow shipment to and through mainland United States.

Option 4. Target the food service industry, hotel, restaurant and institutions.

Option 5. Educate the Consumer on the nutritional value and versatility of presenting the specialty tropical fruit.

Option 6. Pursue cooperative and synergistic efforts with other commodities to enhance the image of Hawaii grown products.

Option 7. Promote the expansion and diversification of export.

Option 8. Cooperate in the development of a multi-commodity marketing organization for those that want to participate.

Option 9. Keep growers and consumers informed of the nutritional, presentable, and value aspects of the specialty tropical fruits.

Option 10. Develop a program to move the organization to a sustained independence and market progression.

Option 11. Develop and maintain a current press kit.

Option 12. Develop a synergistic advertising theme for all Hawaii specialty tropical fruit.

Option 13. Develop Information System Management (ISM) to members. Provide a comprehensive Industry Database and maintain industry statistics.

Comments: _____

_____

_____

Mahalo... Please return this sheet to Linda Huffman.

Issued in furtherance of Cooperative Extension Work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Noel P. Kefford, Director and Dean, Cooperative Extension Service, College of Tropical Agriculture and Human Resources, University of Hawaii at Manoa, Honolulu, Hawaii 96822. An Equal Opportunity/ Affirmative Action Institution providing programs and services to the people of Hawaii without regard to race, sex, age, religion, color, national origin, ancestry, disability, marital status, arrest and court record, sexual orientation, or veteran status.

HITAHR 07.09.93 (.5M)