UF UNIVERSITY of FLORIDA IFAS Extension

Cir1442

Tropical Fruit Pest Management Strategic Plan (PMSP)[1]

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Executive Summary

A Pest Management Strategic Plan was held in Homestead, Florida on March 31, 2003. Participants developed strategic plans for avocado, banana, carambola, guava, lychee, longan, mamey sapote, mango, papaya, passionfruit, sapodilla, and sugar apple. There are several areas of action which seem to be common to the tropical fruits in general. First, there has been change in water flow in the area due to the Everglades restoration plan. Saturated conditions are exacerbating existing fungal diseases and causing new problems to surface. Secondly, there is a lack of education with regard to flower predation and disease control during bloom. There are also a number of fruit quality issues which must be addressed both pre- and post-harvest. Finally, insect problems are often specific to a crop, except for pests such as scales and mealybugs, which have wide host ranges, and are recognized as problems for most of the tropical fruits.

Introduction

A Pest Management Strategic Plan for the Florida tropical fruit industry was conducted at the University of Florida/IFAS Miami-Dade County Extension Auditorium. While crop profiles have been prepared for 16 of the fruits grown in southern Florida, strategic plans were promulgated for a dozen tropical fruits. These crops are: avocado, mango, papaya, lychee, longan, carambola, guava, banana, passionfruit, sugar apple, sapodilla, and mamey sapote. Also included are minor notes for five fruits: Tahiti lime, key lime, kumquat, pummelo, and jackfruit. Collectively, these crops generate approximately $170 million for the economy of South Florida.

Pest Management Strategic Plans are usually prepared for individual crops. However, the situation for tropical fruits is quite different from conventional minor crops. Specifically, multiple types of fruit are grown by the same persons, as evidenced in the list of attendees. Secondly, the extension and research personnel for all of the tropical fruits are the same people as well. There is also pest overlap in a number of situations. Since the majority of tropical fruit acreage is in the most distal portion of the State of Florida, it was determined by all of the organizers and advisors of the PMSP that the most efficient use of resources would be a meeting that addresses all of the tropical fruit crops that are in commercially viable production.

Consequently, this PMSP focuses on the individual needs of approximately a dozen different crops. It will be evident upon review of the individual needs that there are several overarching areas of research and extension/regulation to address. When common pest names are mentioned in this document, the scientific name is either already in the

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crop profile, or presented here. Sometimes, pest taxa are unknown or there are multiple species of a particular pest type that occur (e.g. thrips and mealybugs). All pesticides are referred to by the common name of the active ingredient. Each fruit will be individually discussed and common problems of the tropical fruits will be summarized.

Avocado

In 2000-2001, 6,000 bearing acres in Florida produced just over one million bushels, which occurred for the first time since Hurricane Andrew. At an average price of $14.60 per bushel, the crop for this season was valued at $15.2 million. At this same time, Florida accounted for nine percent of the acreage and twelve percent of the production nationally, but only accounted for four percent of the value, owing to the fact that Florida avocados sell for about one-third of the price garnered by California avocados. Over 90 percent of Florida avocado is grown in Miami-Dade County.

Insect management is currently quite simplistic due to a lack of registered materials. Natural predators, petroleum oil, and soaps are used for mite, aphid, and scale management, malathion and permethrin are used as general non-specific insecticides, fenoxycarb is used for fire ant management, and B.t. is used to manage lepidopteran pests. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. There is one organophosphate insecticide registered for avocado (malathion). It does not appear to be a major management tool, since only 11 percent of growers reported using it.

Key pest species identified during the PMSP for avocado include thrips, mirids, looper, and mites, in that order. Mirid and thrips biology and sampling techniques are known, but there is no economic threshold for bloom damage. Many growers appear to be unaware of this feeding as well as the future ramifications. *Frankliniella* spp. appear to be the most problematic of this group. Red-banded thrips is also an intermittent problem. Pending registrations of milbemectin, abamectin, and buprofezin should soon provide tools with which to manage these pests. Imidacloprid obtained a tolerance for avocado on June 13, 2003.

For avocado looper, growers expressed frustration with the fact that there did not seem to be enough lead time to spray (i.e., no economic threshold). This is a question of whether this pest can be controlled based on population dynamics or whether IGRs or pheromones should be considered as potential tools since the biology of this species is known. Resistance was also suspected by some growers. Spinosad is newly registered for avocado.

Citrus red mite (*Panonychus citri*) was added to the list of mites that affect avocado. It is currently not managed. Growers questioned as to whether non-management might lead to premature leaf abscission prior to bloom which may then lead to reduced fruit set and crop yields. Sampling strategies for this mite need to be elucidated. For bud mite, biology is not well known.

Several growers expressed interest in education regarding the quarantine restrictions and action plans associated with Mediterranean fruit fly and other pests that trigger this process. A USDA ARS participant noted that this was an active program at the Miami laboratory.

Emerging insect pests for avocado (and all tropical fruits in general) include pink hibiscus mealybug (*Maconellicoccus hirsutus*), lobate lac scale (*Paratachardina lobata lobata*), and Sri Lanka weevil (*Myllocerus undecimpustulatus*). There has been some efficacy research done with this weevil and zeta-cypermethrin, phosmet, and *Beauveria bassiana* on tropical fruit through IR-4, but only *Beauveria bassiana* is available to tropical fruit growers. Phosmet and zeta-cypermethrin are not in the current pipeline for avocado.

Disease management is also quite rudimentary in avocado groves. Copper materials and sulfur are the two materials employed to reduce fungal growth. Root protectants such as mefenoxam and fosetyl-Al are only used when needed (during saturated soil conditions). There are no carcinogen, IPM, or other concerns with the currently registered materials.

Key diseases identified for avocado during the PMSP include phytophthora root rot (PRR), pseudocercospora spot (blotch) = anthracnose, stem end rot, and scab, in that order. Since the Everglades restoration plan has generally raised the water table levels in the tropical fruit growing area, the duration, extent, and frequency of saturated soil and flooding has increased. Pathologists believe that fungicide use in nurseries masks phytophthora infection, which goes through its final stages in the field. This is also the mechanism by which clean soil becomes infested. Rootstock resistance needs to be identified. Possible needs also include injection use of fosetyl-Al to combat PRR in bearing trees.

Anthracnose is the number one fruit disease. There are no models being used for prophylactic prevention, and there is only one fungicide (azoxystrobin) to address this disease. Consequently, rotational partners and schemes are needed to prevent resistance to this class of fungicides. A mixture of pyraclostrobin and boscalid (BAS 516) is pending

registration, but this product also contains a strobilurin fungicide, which should not be rotated with other fungicides of this class.

Stem end rot (caused by several different fungi) is an important post-harvest disease. No post-harvest fungicides are registered for avocado in Florida.

Other diseases of concern are powdery mildew (*Oidium* spp.) and leaf spot (*Pseudocercospora purpurea*), especially in non-topped trees. Powdery mildew also attacks flowers resulting in reduced bloom and fruit set.

Several species of grove weeds such as lantana, parthenium, pilea, and possumvine (*Cissus cissiodes*) appear to be recalcitrant to glyphosate. Carfentrazone is pending registration for all of the tropical fruits and efficacy work with this herbicide on these species was suggested.

Research Priorities for Florida Avocado

1. Establish the economic threshold for thrips damage on avocado blooms.

2. Examine avocado looper resistance with existing compounds and mating disruption with pheromones (if available).

3. Study the biology/phenology of bud mite on avocado and elucidate sampling scheme for citrus red mite.

4. Breed phytophthora-resistant rootstock.

5. Investigate efficacy of carfentrazone-ethyl on problematic weed species.

6. Investigate efficacy of newly registered insecticides on emerging pest problems.

Education Priorities for Florida Avocado

1. Advise growers of the effect/threshold for thrips damage to blooms and subsequent fruit set.

2. Present growers with a pamphlet that addresses their interest in the quarantine process.

3. Educate growers with respect to rotation of fungicides to reduce the rate of resistance to strobilurins.

Regulatory Priorities for Florida Avocado

1. Regulatory Priorities for Florida Papaya1. Register a fungicide other than a strobilurin (e.g., thiophanate-methyl) for rotation to reduce rate of resistance development.

2. Register a post-harvest fungicide for stem-end complex.

3. Register injection use of fosetyl-Al for PRR control.

4. Continue registration process for abamectin/milbemectin (at least one), buprofezin, BAS 516, and carfentrazone-ethyl.

Mango

The mango acreage for 2000 was reported to be 1,675 acres, which represents approximately 168,000 trees. Mango acreage has been constant at the 1,700 to 1,800 acre range since Hurricane Andrew struck in fall of 1992. Prior to this event, production in the state was near 3,000 acres. In the last year for which production statistics are available (1997), a reported mango crop of 100,000 bushels (5.5 million pounds) was harvested. At a price of $14.50 per bushel, this crop was worth $1.45 million. Over eighty percent of mango production occurs in Miami-Dade County. The remaining acreage is located in counties in the vicinity of Miami-Dade County.

Insect management in mango relies on a mixture of natural predators, petroleum oil, malathion, and methidathion for the majority of pest problems such as scale, mealybug, and thrips. Pyrethrins + rotenone, B.t., and imidacloprid were employed to a minor extent by mango growers for use in managing lepidopteran pests and sucking/chewing pests. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. For mango, organophosphate insecticides appear to a major component of pest management schemes, although growers still report problems with pests that these materials theoretically control. A tolerance for pyriproxyfen (scales) on mango was granted on May 14, 2003.

Key insect species identified for mango include scales, thrips, and mealybugs, in that order. Mango white scale (*Aulacaspis tubercularis*) is a quarantine pest in nurseries now. The scale's biology is generally understood, but effect on the tree is not well documented.

Thrips damage to the panicle (flowers) is unproven, and if damage is occurring, no economic threshold has been determined. Red-banded thrips is also an intermittent problem.

Emerging insect pests for mango include white mango scale, pink hibiscus mealybug, lobate lac scale, and Sri Lanka weevil, especially in nursery settings.

Disease control in mango hinges on three active ingredients (copper, sulfur, and ferbam). These materials do manage the key diseases of mango (anthracnose and powdery mildew), but not to the extent that growers would like. There are no carcinogen, IPM, or other concerns with the currently registered materials.

Key diseases identified for mango include anthracnose = powdery mildew, blossom blight, and post-harvest (stem-end rot) fungi, in that order. Either anthracnose or powdery mildew can affect blossom viability. Although occurrence models exist for both of these diseases on mango, control models do not exist. There are currently two fungicides registered for both anthracnose (azoxystrobin and ferbam) and powdery mildew (sulfur and potassium bicarbonate) on mango. These materials should be tested as rotational partners during bloom and early fruit set. There was also a need identified for possible rain-fastness studies for these fungicides - due to the high precipitation in southern Florida. There has been some efficacy research done on mango through IR-4 with tebuconazole, trifloxystrobin, and cyprodinil + fludioxonil on anthracnose, but more testing has been recommended. The tebuconazole registration for mango is pending, but the other two materials are not in the regulatory que. Azoxystrobin is newly registered for mango and this will provide a much needed tool to manage anthracnose.

Although TBZ (thiabendazole) is registered as a post-harvest fungicide for mango, growers indicated that post-harvest materials are needed. Waste water disposal, cost issues, and a shift in the market for Florida mango has precluded the use of TBZ.

Several species of grove weeds (as stated in the avocado section) appear to be recalcitrant to glyphosate. Carfentrazone is pending registration and efficacy work with this herbicide on these species was suggested. Sethoxydim (a grass material) registration is also pending.

Research Priorities for Florida Mango

1. Determine the effect of thrips feeding on bloom viability and establish the economic threshold for thrips damage on mango blooms.

2. Examine extent of white mango scale damage on mango.

3. Determine efficacy/rotational pattern for existing/new fungicides.

4. Examine rainfastness of available fungicides.

5. Investigate efficacy of newly registered insecticides/fungicides on key and emerging pests.

6. Determine the fungicides (imazalil, OPP) other than TBZ that will control post-harvest diseases.

Education Priorities for Florida Mango

1. Advise growers of the effect/threshold for thrips damage to blooms and subsequent fruit set.

2. Advise growers of the availability of materials for anthracnose and powdery mildew as well the rotational pattern with new material (azoxystrobin).

3. Educate growers with respect to rotation of fungicides to reduce the rate of resistance to strobilurins.

Regulatory Priorities for Florida Mango

1. Register a post-harvest fungicide other than TBZ for post-harvest fungus control.

2. Continue registration process for pyridaben, tebuconazole and carfentrazone-ethyl.

Papaya

In Miami-Dade County, between 1989-90 (before Hurricane Andrew), papaya acreage was approximately 375 acres. Acreage then increased to about 400 acres in this county by 1994-two years after Andrew. Two years after that (1996), acreage in Miami-Dade County declined to 250 acres. In that year, over 90 percent of papaya was grown in Miami-Dade County. And half of that crop was sold outside of the county. Based on the acreage in 1996, the papaya crop was worth an estimated $1.6 million.

Insect management in papaya relies on a mixture of natural predators, permethrin, malathion, and pyrethrins + rotenone for the majority of pest problems such as papaya fruit fly, scale, mealybug, and twospotted spider mite. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. There is one organophosphate insecticide registered for papaya (malathion). It does not appear to be a major management tool, since only 17 percent of growers reported using it. A tolerance for pyriproxyfen (scales) on papaya was granted on May 14,

2003 and a tolerance for imidacloprid (scales, mealybugs) was granted on June 13, 2003.

Key pest species identified for papaya include mites = scales, papaya fruit fly, and mealybugs, in that order. There is a new eriophyid mite that is awaiting identification. Biology for twospotted spider mite is known, but there is no current economic threshold for it in terms of sampling and monitoring. Another observation was that papaya is prone to spray burn in hot dry weather when mites are typically most damaging. There has been some efficacy research done on mites in papaya through IR-4 with milbemectin, bifenazate, novaluron, and pyridaben, but more testing has been recommended. Abamectin and pyridaben registrations for papaya are pending.

Scales are a continuous problem. There tends to be population explosions when "hard" (permethrin, malathion) insecticides are used for mite control. This problem is interrelated.

The biology of papaya fruit fly is known, and a pheromone is available for commercialization from USDA ARS. Growers are currently using shape and color cues for trapping control. It was stated that since it is known that infestation starts from the outside and progresses inward, that border sampling should be stressed as the best practice.

There appears to be some confusion as to the vector of papaya ringspot virus in Florida. Literature seems to indicate that it is the green peach aphid. However, this aphid is often not found even though PRSV moves into the papaya plantings.

The papaya mealybug lives in the very top of the canopy, making control difficult.

Emerging insect pests for papaya include pink hibiscus mealybug, lobate lac scale, and Sri Lanka weevil.

Disease control in papaya mainly centers around mancozeb, with occasional use of copper, mefenoxam, benomyl, and sulfur. The registration of azoxystrogin has mitigated the loss of benomyl. Chlorothalonil is classified as a B2 carcinogen and maneb and mancozeb metabolites have been linked to tumor formation. Maneb and mancozeb will also be reassessed at the national level in the future. There are no IPM or other concerns with the currently registered materials.

Key diseases identified for papaya include papaya ringspot virus = papaya mosaic virus (potex virus), anthracnose, and post-harvest fruit spots caused by several different fungi, in that order. Growers noted that mixed infections of PRSV and PMV take down papaya plants quickly. Resistance to PRSV in Florida papaya is currently being genetically engineered through UF/IFAS. Perhaps a similar process can be initiated for PMV. A systemic activated response (SAR) material (acibenzolar) may also prove useful in mitigating the effects of viral infection.

There are currently a number of fungicides registered for anthracnose on papaya (azoxystrobin, chlorothalonil, maneb, mancozeb). There has been some efficacy research done on papaya through IR-4 with tebuconazole, pyraclostrobin, and cyprodinil + fludioxonil on anthracnose, but more testing has been recommended. Registration of myclobutanil is pending. These materials need to be tested as rotational partners.

Members added corynespora spot (brown spot) as a key disease, although it is easily controlled with mancozeb. Another topic for grower education is phytophthora blight - which can kill a plant extremely quickly when water saturation occurs for any long duration. It is not manageable currently.

Although TBZ (thiabendazole) is registered as a post-harvest fungicide for papaya, growers still indicated that post-harvest products are needed. As with mango, waste water disposal and cost issues have precluded the use of TBZ.

Most papaya is now grown using soil fumigation and plastic mulch culture with drip irrigation. Both carfentrazone and sethoxydim are in line to be registered for papaya, and these in addition to those herbicides already registered (glyphosate, diuron, oxyfluorfen, paraquat, oryzalin, and pelargonic acid) should provide enough options for complete weed control in row middles.

Research Priorities for Florida Papaya

1. Determine the sampling/monitoring economic threshold for spider mite damage and population dynamics associated with current pest control programs.

2. Examine scale population dynamics in relation to existing and newly registered insecticides.

3. Determine efficacy/rotational pattern for existing fungicides as well as those that are newly registered.

4. Examine papaya sensitivity to formulating agents that may be causing spray burn.

5. Investigate potential of SAR compound (acibenzolar) on virus control.

6. Determine the fungicides (imazalil, OPP) other than TBZ that will control post-harvest diseases.

Education Priorities for Florida Papaya

1. Advise growers of the effect on scales/mites when "hard" insecticides are used.

2. Advise growers of the pattern for papaya fruit fly sampling (border intensive).

3. Educate growers with respect to complete coverage of the papaya canopy to control mealybug.

4. Educate growers on the management of corynespora spot and phytophthora blight control.

5. Educate growers with respect to rotation of fungicides to reduce the rate of resistance to strobilurins.

Regulatory Priorities for Florida Papaya

1. Register a post-harvest fungicide other than TBZ for post-harvest fungus control.

2. Continue the registration process for pyridaben, abamectin, myclobutanil and carfentrazone-ethyl.

3. Release of newly developed genetically-modified cultivars (when available).

4. Registration of SAR compound if effective in virus control.

Lychee

In 1995-96, average lychee yields were 8,750 pounds per acre. With a pack-out of 70 percent and a price of $3.75 per pound, income from an acre of lychee would have been worth approximately $23,000. Lychee is one of two tropical fruits (the other being longan) that have increased in planting acreage greatly over the decade of the nineties. During the ten years from 1990, lychee acreage increased 300 percent, from 200 acres to approximately 600 acres. In 1995-96, 95 percent of lychee was shipped out of Miami-Dade County.

Insect management in lychee relies on natural predators and tebufenozide (for webworm). There is minor useage of petroleum oil, azadirachtin, pyrethrins + rotenone, and B.t. There are no OP, carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for imidacloprid (scales) on lychee was granted on June 13, 2003 and a tolerance for buprofezin (scales, mealybugs) was granted on June 25, 2003.

Key pest species identified for lychee include bark scale, thrips = mirids, mites, and webworm, in that order. There are two organisms, bark scale and a moth in the *Marmara* genus, that use the bark as a common habitat. Marmara causes a deformity known as corky bark on lychee trees. The role of the scale and other factors (e.g. a fungal pathogen, F*usarium decemcellulare,* has been recovered from affected trees) in the development of this problem need to be investigated. Little is known regarding the scale biology.

Thrips and mirids are an emerging problem during late flowering (see avocado). However, imidacloprid has been recently granted a tolerance in lychee and spinosad is registered for thrips management in lychee.

Citrus red mite (*Panonychus citri*) on leaves and citrus flat mite (*Brevipalpus lewisi*) on fruit are the main mite problems. Biology on lychee is unknown and timing/sampling economic thresholds need to be established. Diflubenzuron, abamectin, and milbemectin registrations are pending for lychee.

There is some biology/seasonality research for webworm, but no economic thresholds have been established. Biological control is strongly suggested for this species, although methoxyfenozide is in the registration process. There has been some efficacy research done on lychee through IR-4 with fenpropathrin, abamectin, and thiacloprid on fall armyworm, but more testing has been recommended. More research was also suggested for sampling/monitoring and timing spraying of methoxyfenozide.

Emerging insect pests for lychee include root weevil on sandy and marl soils.

Disease control in lychee mainly centers around copper hydroxide to control anthracnose. There are no carcinogen, IPM, or other concerns with the few currently registered materials.

Key diseases identified for lychee include anthracnose, coffee stain spot, and pythium root rot, in that order. Anthracnose is the number one disease affecting flowers and later fruit. There are no models available for prophylactic prevention, and there is only one fungicide (azoxystrobin) to address this disease. There has been some efficacy research done on lychee through IR-4 with tebuconazole,

chlorothalonil, pyraclostrobin, and cyprodinil + fludioxonil on anthracnose, but more testing has been recommended. Tebuconazole, mancozeb, and the mixture of cyprodinil + fludioxonil are pending for lychee. Consequently, rotational schemes need to be elucidated.

The lychee growers also described a "coffee stain" disorder that occurs on the fruit that has recently become quite severe in occurrence. It is unknown whether this is physiological or a disease.

Pythium root rot affects trees growing in wet soil. Mefenoxam is NOT in the pending list for this crop.

Both carfentrazone and sethoxydim are in line to be registered for lychee, and these in addition to those already registered (glyphosate and pelargonic acid) may provide enough options for complete weed control.

Research Priorities for Florida Lychee

1. Investigate the corky bark complex (i.e., causal organism(s), management).

2. Examine mite population dynamics and determine thresholds.

3. Determine efficacy/rotational pattern for imidacloprid and spinosad use in flower predator management.

4. Optimize the IGR methoxyfenozide (timing, frequency) and scout for biocontrol agents for lychee webworm.

Education Priorities for Florida Lychee

1. Advise growers of the effect of scales on bark health and how to sample/examine.

2. Advise growers on the method for scouting for lychee webworm.

3. Educate growers on the necessity of prophylactic timing with respect to anthracnose management.

4. Educate growers with respect to rotation of fungicides to reduce the rate of resistance to strobilurins.

Regulatory Priorities for Florida Lychee

1. Continue the registration process for diflubenzuron, abamectin/milbemectin (at least one), methoxyfenozide, tebuconazole, cyprodinil + fludioxonil, and carfentrazone-ethyl.

2. Add mefenoxam to the regulatory queue.

Longan

In 1995-96, longan average yields were 8,000 pounds per acre. With a pack-out of 90 percent and a price of $3.60 per pound, income from an acre of longan would have been worth approximately $26,000. During the ten years from 1990, longan acreage increased 550 percent, from 72 acres to approximately 400 acres. In 1995-96, 85 percent of longan was shipped out of Miami-Dade County.

Insect management in longan relies on natural predators and tebufenozide (for webworm). There is minor useage of petroleum oil, azadirachtin, pyrethrins + rotenone, and B.t. There is one OP (methidathion) available to longan growers, but only about a quarter employed the material. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for imidacloprid (scales, thrips) on lychee was granted on June 13, 2003 and a tolerance for buprofezin (scales, mealybugs) was granted on June 25, 2003.

Key pest species identified for longan include banana-shaped scale, mealybugs, fire ant, and mites, in that order. The banana-shaped scale and the associated sooty mold that grows on the skin of the longan fruit are causing problems in the packinghouse and in shipping fruit out-of-state. There has been some efficacy research done on longan through IR-4 with buprofezin, pymetrozine, pyriproxyfen, imidacloprid, and abamectin on banana-shaped scale and bark scale, and results are promising, but more testing has been recommended. No work exists on scale monitoring/sampling and economic thresholds need to be determined.

Mealybug (and scales) can quickly affect the panicle. Economic thresholds are needed.

Since the branch with fruit intact is the final form at pack out, this commodity has been refused in California for the presence of various ants (fire ant, big-footed ant). Hydramethylnon is pending for longan, and this may reduce this problem. Additionally, S-methoprene and pyriproxyfen are available as baits in non-bearing fruit trees. This may mean trying to control fire ants in the non-bearing season until bearing season options are registered.

Citrus red mite is the main mite problem, and the biology on longan is unknown. Sampling and economic thresholds need to be established.

In-season diseases do not drastically affect longan growth or fruit production. Rather, it is the sooty mold and other unidentified diseases that affect post-harvest quality. Optimum conditions need to be determined for the post-harvest storage of longan to discourage the growth of these organisms. There are no carcinogen, IPM, or other concerns with azoxystrobin, the only currently registered material.

A nursery grower stated that pythium root rot is responsible for loss of approximately 20 percent of longan seedlings in this setting. Mefenoxam is NOT in the pending list for this crop, but it is labeled for nursery use.

IR-4 is currently petitioning the EPA to have all things undergoing registration for lychee apply to longan as well. If this is the case, both carfentrazone and sethoxydim are in line to be registered for lychee, and these in addition to those already registered (glyphosate and pelargonic acid) may provide enough options for complete weed control in longan.

It was noted that methyl anthranilate does not work as a bird repellent. Birds pierce the fruit. An alternative is needed.

Research Priorities for Florida Longan

1. Optimize scale and mealybug control and resistance management with the newly registered materials.

2. Examine grove fire ant management with various bearing and non-bearing season materials.

3. Examine mite management with those materials due to be registered on lychee.

4. Determine citrus red mite biology on longan and determine the economic threshold.

5. Identify a post-harvest fungicide control agent.

6. Determine a method/identify a chemical to discourage bird piercing of fruit.

Education Priorities for Florida Longan

1. Advise growers on how to sample for scales and mites in the grove.

2. Advise growers on how to sample for ants in the packinghouse.

3. Educate nursery growers on the proper use of mefenoxam.

Regulatory Priorities for Florida Longan

1. Continue the lychee registration process for diflubenzuron, abamectin/milbemectin (at least one), methoxyfenozide, tebuconazole, cyprodinil + fludioxonil, and carfentrazone-ethyl that will also suffice for longan.

Carambola

The Florida production of carambola in 1994 (530 acres) represented 93 percent of all carambola grown in the U.S. The carambola acreage for 1996 was reported to be 650 acres, which represents approximately 104,000 trees. In the last year for which production statistics are available (1996), a reported carambola crop worth $17.4 million was harvested. With an average yield per acre of 40,000 pounds, a packout of 60 percent, and the price per pound of $1.40, an acre of carambola was worth $33,600. An estimated 98 percent of carambola sales ($17.1 million) were made outside of Miami-Dade County in 1996. The reported carambola acreage in 2000 was 250 acres.

Insect management in carambola relies on natural predators, petroleum oil, methidathion, and pyrethrins + rotenone. There is also use of fenoxycarb for ant management. There is one OP (methidathion) available to carambola growers, but less than a quarter of growers employed the material. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for imidacloprid (scales) on carambola was granted on June 13, 2003.

Key insect species identified for carambola include scales, mites, thrips, and fruit feeding insects, in that order. Black tortoise scale (*Toumeyella* sp.) and plumose scale were reported as the two most troublesome scale species for carambola. There has been some efficacy research done on carambola through IR-4 with buprofezin, pymetrozine, pyriproxyfen, imidacloprid, and abamectin on scales, and results are promising. A tolerance has been established for pyriproxyfen. Although methidathion is available for use on bearing carambola to control scales, there has been some reports of phytotoxicity with this insecticide. Growers believed those experiencing problems need to be educated as to the environmental conditions under which methidathion should be applied (high humidity/mild temperatures/adequate soil moisture). Consequently, integrated programs with oil, methidathion, and pyriproxyfen/imidacloprid (when available) should be constructed to determine which

are most efficient at controlling the aforementioned scale species.

Flower predation for carambola is poorly understood. It was hypothesized that mites or thrips may be responsible for such damage, but there was no consensus.

There is a marketing/quality problem with regard to stink bugs, mites, and mealybugs on the fruit. The population increases intermittently observed do not seem to be explainable based on common insect dynamics. It was suggested that frequency/monitoring/sampling studies for these three groups be conducted. There are currently three general insecticides pending registration (bifenthrin, deltamethrin, and abamectin).

There are also a number of ant species which feed upon carambola. Since fire ant is a quarantine pest, the lack of control of this group of pests limits interstate shipment of the fruit. Hydramethylnon is not in the regulatory que for carambola and fenoxycarb can only be used in non-bearing carambola. Additionally, S-methoprene and pyriproxyfen are available as baits in non-bearing fruit trees. This may mean trying to control fire ants in the non-bearing season until bearing season options are registered.

Disease control in carambola mainly centers around copper hydroxide to control anthracnose, sooty blotch, and leaf spot. There are no carcinogen, IPM, or other concerns with the few currently registered materials.

Key diseases identified for carambola are sooty blotch (*Peltaster* sp.), red-spotting for fruit (multiple pathogens including *Cercospora*), and root rot. The fungus causing sooty blotch is slow-growing. Some efficacy research supported by a local commodity group has been done on carambola with benomyl, mancozeb, and metallic copper for sooty blotch, but more testing is recommended. Growers recommended trials with some of the new classes of fungicides. Azoxystrobin is now labeled for carambola, but copper may cause leaf damage on carambola, so there is only this problematic rotational partner for azoxystrobin in this crop.

With regard to carambola root rot, one researcher noted that carambola root growth is different in the nursery compared to the field (i.e., continuous root growth in the nursery leads to good control with soil-applied fungicides while intermittent root growth in the field results in less efficacy). Mefenoxam is on the pending registration list for carambola. Additionally, a biological control fungus, *Trichoderma harzianum*, is available for treating roots, but its efficacy against this disease has not been studied.

Red spotting of carambola fruit, as well as other tropical fruit, has been noted. It was suggested that an effort be made to characterize the organism(s) that cause this damage.

Research Priorities for Florida Carambola

1. Optimize scale control and resistance management with the present and newly registered materials.
2. Examine grove fire ant management with various bearing and non-bearing season materials.
3. Examine flower development and identify pests that cause damage.
4. Optimize fruit-damaging insect control.
5. Determine optimal fungicide rotation to control sooty blotch and prevent resistance.
6. Determine efficacy of biological fungicides against root rot.

Education Priorities for Florida Carambola

1. Advise growers regarding the proper use of methidathion for scale control.
2. Advise growers on non-bearing options for ant control.

Regulatory Priorities for Florida Carambola

1. Continue the registration process for bifenthrin/deltamethrin (at least one), abamectin, mefenoxam, and carfentrazone-ethyl.
2. Register an ant control compound for bearing season management.
3. Register a rotational partner for azoxystrobin.

Guava

In 1990, acreage of guava in Florida approached 80 acres. By the middle of the decade, this fruit was grown on nearly 200 acres. The 1995-1996 average yield of guava in Florida was 25,000 pounds per acre. At a packout rate of 70 percent and a price of $1.15 per pound, the Florida crop was worth approximately $3 million.

Insect management in guava relies on natural predators and malathion (reported use by 40 percent of growers). However, spinosad has been registered since this survey. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for imidacloprid (scales, mealybugs) on guava was granted on June 13, 2003.

Key insect species identified for guava include Caribbean fruit fly, mealybugs, mites = stink bugs and green shield scale (*Pulvinaria psidii*), in that order. CFF is by far the most important insect problem associated with guava. The biology of this fly is understood, and the USDA ARS is working on a synthetic food-based lure in addition to the parasitic wasp and sterile fly release programs. This group is also working on trap and kill technology for the CFF. Current cultural control practices for white guava include bagging the fruit while still on the plant to protect it from CFF. The red and pink guava sold on the local fresh market are not bagged but sprayed to protect fruit from CFF. Eradication is the desired process for this pest. There has been some efficacy research done on guava through IR-4 with fenpropathrin, imidacloprid, and abamectin on lepidoptera, and results are promising.

However, even with the protection of the bag, it appears that the another key pest has integrated its feeding into the current CFF control practice. Mealybugs are a problem at the peduncle junction both in nonbagged and bagged guava. Perhaps a treated bag is needed for the bagged fruit.

False spider mite (*Brevipalpus phoenicis*) and stink bugs were reported to damage the peel. There has been some efficacy research done on guava through IR-4 with chlorpyrifos and abamectin tested on mites, but more testing is recommended. Abamectin use is pending. Imidacloprid registration may provide a tool for stink bug control.

Although reported in the crop profile to be major pests of guava, redbanded thrips and guava moth appear to be controlled incidentally when spray programs are not "hard" on the beneficials.

Green shield scale was reported to be a problem in nursery guava production. Buprofezin registration is pending for use in controlling scale insects.

Disease control in guava mainly centers around copper hydroxide to control anthracnose and leaf spot. There are no carcinogen, IPM, or other concerns with the few currently registered materials.

Key diseases identified for guava are anthracnose and algal spot. Although bagging provides protection from most insects (and post-bloom diseases), anthracnose often begins during bloom, when bagging cannot be done. There has been some efficacy research done on guava through IR-4 with tebuconazole, trifloxystrobin, and cyprodinil + fludioxonil for anthracnose, but more testing is recommended. Although azoxystrobin is now labeled for guava, resistance will occur if there are no rotational partners for this fungicide.

Since copper compounds appear to be somewhat phytotoxic to guava fruit, algal spot has become more of a problem in this tropical fruit than others. Alternative control is needed.

Several growers conversed regarding a perceived decline in guava which may involve the herbicide glyphosate. At this point, the observation is anecdotal.

It was also noted that nematodes can be injurious to guava. The damage appears to be cultivar dependent, and this may require a combination of research and education.

Research Priorities for Florida Guava

1. Examine efficacy of newly registered materials on mealybug and stinkbug control.

2. Examine biology of false spider mite on guava.

3. Develop an integrated CFF management program.

4. Determine an acceptable candidate for algal spot management.

5. Determine optimal fungicide rotation to control anthracnose and prevent resistance.

6. Determine if nematode damage is cultivar-specific and construct possible mitigation plans.

Education Priorities for Florida Guava

1. Present growers with a fully-integrated system for bagged white guava.

2. Cooperate with growers and USDA on a CFF eradication plan.

3. Cooperate with growers on the nematode and glyphosate phytotoxicity questions.

Regulatory Priorities for Florida Guava

1. Continue the registration process for abamectin, buprofezin, and carfentrazone-ethyl.

2. Register a rotational partner for azoxystrobin which may also control algal spot.

Banana

Although a crop profile does not currently exist for banana, key insects identified for banana include mealybugs, thrips, and a cucumber beetle, in that order. Growers reported that unspecified species of thrips and mealybugs are affecting fruit. Since there are few banana growers, it is difficult to know how great of a problem these pests pose. Spinosad is newly registered for banana. Pending insecticides for banana include imidacloprid and bifenthrin.

Growers also reported that a cucumber beetle was causing problems on banana, but were unsure whether it was spotted or striped cucumber beetle.

Key diseases identified for banana are the Sigatoka leaf spots (black and yellow), Panama disease, and moko. Specialists present at the meeting concurred that these diseases were managed culturally, rather than chemically. Although there is currently a triazole fungicide (fenbuconazole) and a strobilurin fungicide (azoxystrobin) registered for banana, new chemistries, such as myclobutanil and acibenzolar are pending.

Two species of nematode - spiral (*Helicotylenchus multicynctus*) and burrowing (*Radopholus similis*), damage banana in southern Florida. Oxamyl is currently registered for banana.

One researcher pointed out the banana is often propagated vegetatively with rhizomes (suckers). Nematodes and fungal pathogens can be minimized by thoroughly removing the outer layers of the rhizome. It was also suggested that tissue culture plantlets be employed whenever possible, as they are free of bacterial, fungal, and nematode pests.

Research Priorities for Florida Banana

1. Investigate damage by cucumber beetles.

2. Identify thrips and mealybug species that damage banana fruit.

3. Determine efficacy of new or pending insecticides on thrips and mealybugs.

4. Determine efficacy of new or pending fungicides on banana diseases.

Education Priorities for Florida Banana

1. Educate growers on nematode and propagation sanitary practices.

2. Encourage growers to propagate or utilize tissue culture plantlets.

Regulatory Priorities for Florida Banana

1. Continue the registration process for imidacloprid, bifenthrin, myclobutanil, and acibenzolar.

Passionfruit

Like banana, a crop profile does not exist for this fruit, but several members provided input with regard to pest management. Key insect species identified for passionfruit include false spider mite, pit scale (*Asterolecanium* sp.), and thrips, in that order. False spider mite and pit scale were reported to damage fruit, while thrips damage flowers. Abamectin registration is pending for mite management, while pyriproxyfen is pending for scale control. Malathion is reregistered in passionfruit, and it should be investigated with these other pending chemistries to address the pest complex for passionfruit. A tolerance for imidacloprid (scales, thrips) on passionfruit was granted on June 13, 2003.

Key diseases identified for passionfruit mainly concern fruit quality, except nectria canker on the stem and anthracnose on the leaves. Anthracnose is also observed on the fruit, as well as alternaria, cladosporium, and septoria. Azoxystrobin is now labeled for passionfruit, as is chlorothalonil, which provides the minimum rotation for anthracnose management. Copper is also labeled for passionfruit, and mancozeb is a proposed fungicide, but the current options may have to be optimized to control the noted fruit diseases.

Research Priorities for Florida Passionfruit

1. Investigate flower damage by thrips and fruit damage by mites and scales.

2. Determine efficacy of new or pending insecticides on mites, scales, and thrips.

3. Determine efficacy of newly registered fungicides on passionfruit diseases.

Education Priorities for Florida Passionfruit

1. Educate growers on scouting for mites, scales, and thrips.

Regulatory Priorities for Florida Passionfruit

1. Continue the registration process for abamectin, pyriproxyfen, and carfentrazone-ethyl.

Sugar Apple

The 1995-96 Florida production of sugar apple was 20,000 pounds. At an average seasonal price of $3.00 per pound and a packout of 90 percent, the crop was estimated to be worth $54,000. The acreage of sugar apple peaked in 1989-90 at 75 acres. Hurricane Andrew affected established trees, and as of 2000, acreage of sugar apple was 15 acres. In 1995-96, 10 percent of sugar apple was shipped out of Miami-Dade County, owing to the fragile nature of this fruit.

Insect management in sugar apple relies on natural predators, petroleum oil, and azadirachtin. There is one OP (methidathion) available to sugar apple growers, but none of them reported the use of the material. There are no carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for pyriproxyfen (scales) on sugar apple was granted on May 14, 2003.

There is little sugar apple acreage to cooperate with, but plantings appear to be increasing. Key insect species identified for sugar apple include the annona seed borer (ASB), mealybugs, leafhoppers, scales, and twospotted spider mite. Much work has been done with the ASB, and some attractant work has been done by USDA ARS.

Mealybugs, leafhoppers, and scale insects all affect sugar apple. Initial work with *Beauveria bassiana* has shown promising results for this fruit tree. Pyriproxyfen should make a good rotational partner for methidathion for scale control.

Twospotted spider mite is a reported problem in both nursery and field settings. Control of TSSM in the field leads to less defoliation, which leads to less wind and sunburn of the fruit. There are no specific miticides on the regulatory horizon.

One critical problem with all fruit trees in the annona group is poor or incomplete pollination, since the fruit is an aggregate. Work has been conducted on a pollinator attractant but it is not yet commercialized.

Disease control in sugar apple mainly centers around copper hydroxide to control anthracnose. There are no carcinogen, IPM, or other concerns with the few currently registered materials.

Key diseases identified for sugar apple include leaf rust, which leads to defoliation and subsequent fruit burn. Pythium root rot was also reported as a pressure for sugar apple trees. There were also reports by growers of fruit signs (spots and rots) for which no causative organism has been identified. Azoxystrobin and mefenoxam are now labeled for sugar apple, and these may reduce a number of the reported disease pressures when optimized in the field.

Research Priorities for Florida Sugar Apple

1. Conduct efficacy studies for ASB with insecticides and attractant.

2. Investigate synthetic pollination lures.

3. Conduct efficacy studies for scale, mealybug, and leafhopper management.

4. Optimize mite management with current tools.

5. Determine the casual organisms of fruit rots and spots.

Education Priorities for Florida Sugar Apple

1. Educate growers on the encouraging IPM program with *Beauveria bassiana*.

2. Encourage habitat management for potential pollinators.

Regulatory Priorities for Florida Sugar Apple

1. Register a tool for TSSM management.

2. Continue registration process for carfentrazone-ethyl.

Sapodilla

In 2000, there were approximately 20 acres of sapodilla in production. Insect management in sapodilla relies on natural predators and petroleum oil. There is minor use of soaps and B.t. There are no OP, carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for pyriproxyfen (scales) on sapodilla was granted

on May 14, 2003, and a tolerance for imidacloprid (scales) was granted on June 13, 2003.

Key insect species identified for sapodilla include a fruit and flower moth complex, scales (black tortoise and green shield), mirids, and Caribbean fruit fly, in that order. There has been virtually no research into the fruit flower moth complex, and it is hypothesized that this could include as many as three species of moth. Spinosad and B.t. now are available for lepidopteran control in sapodilla.

Black tortoise scale and shield scale are problems in both nursery and field plantings. Petroleum oil is registered for scale control, and the addition of pyriproxyfen and imidacloprid may lead to a more complete IPM program.

Mirids cause flower damage which in turn leads to poor fruit set.

The considerations for CFF were discussed in the guava section.

Diseases are not currently chemically managed in sapodilla, although some do occur. Diseases identified for sapodilla include leaf spots and a blister or rust disease. The development of leaf spots appears to be affected by microclimate differences and also appears cultivar-dependent.

There also has been a report of a blister or rust which gets worse in cold weather. No research has been conducted on this disease.

Research Priorities for Florida Sapodilla

1. Identify and conduct efficacy studies for the fruit flower moth complex.
2. Research the etiology and epidemiology of the blister/rust disease.
3. Conduct efficacy studies for the blister/rust and leaf-spotting diseases.
4. Optimize scale management with new and current tools.
5. Develop an integrated CFF management program.

Education Priorities for Florida Sapodilla

1. Educate growers on optimizing scale control.
2. Educate growers on possible flower damage and reduced fruit set by mirids.
3. Cooperate with growers to confirm/deny cultivar response to leaf spot damage.
4. Cooperate with growers and USDA on a CFF eradication plan.

Regulatory Priorities for Florida Sapodilla

1. Register copper hydroxide for sapodilla.
2. Continue registration process for carfentrazone-ethyl.

Mamey Sapote

Acreage of mamey sapote has held fairly constant, with approximately 300 acres in production during the decade of the nineties. The 1995-1996 average yield of mamey sapote in Florida was 4,870 pounds per acre. At a price of $2.40 per pound, the Florida crop was worth approximately $3.6 million ($11,700 per acre).

Insect management in mamey sapote relies on natural predators and petroleum oil. There is minor use of B.t. and fenoxycarb is used to manage fire ants. There are no OP, carbamate, carcinogen, IPM, or other concerns with the currently registered materials. A tolerance for pyriproxyfen (scales) on mamey sapote was granted on May 14, 2003, and a tolerance for imidacloprid (scales, leafhoppers) was granted on June 13, 2003. A petition for a pyridaben (mites) tolerance on mamey sapote was submitted on July 3, 2003.

Key insect species identified for mamey sapote include scales (black tortoise, red wax, mining), Cuban May beetles, leafhoppers, and mites. Mining scale (*Howardia biclauis*) has been found on fruit and on trunk areas. No research has been conducted for this species. Black tortoise and red wax scale were reported to be key pests in nursery production. The registration of imidacloprid and pyriproxyfen should provide the tools to construct a scale IPM program.

Cuban May beetles also cause substantial damage to young mamey sapote trees. Use of a nonbearing material may also be appropriate for this pest as well as scale. The May beetle biology is known, but monitoring, frequency, and efficacy data are needed.

Leafhoppers were reported to be problematic on mamey sapote, but species are unknown.

Mites feed on leaves and flowers and injure the blooms. These pests are currently unspecified. Future pyridaben registration will provide a tool for mite management.

No key diseases were reported by the meeting members, but copper hydroxide is used by a little over a third of mamey sapote growers.

Research Priorities for Florida Mamey Sapote

1. Examine the biology of and conduct efficacy studies for the mining scale.

2. Identify, study the biology, and conduct efficacy studies for damaging leafhoppers.

3. Optimize scale management with new and current tools.

4. Conduct efficacy studies for Cuban May beetle.

Education Priorities for Florida Mamey Sapote

1. Educate growers on possible flower damage and reduced fruit set by mites.

2. Cooperate with nursery growers to reduce scale on nursery stock.

Regulatory Priorities for Florida Mamey Sapote

1. Continue the registration process for pyridaben and carfentrazone-ethyl on mamey sapote.

Tahiti Lime, Key Lime, Kumquat, Pummelo

Sadly, the presence of citrus canker in South Florida has nearly eliminated these crops from production. If the fruit is not directly affected by canker, its movement is. Because these species are in the citrus family, there are many pest management tools available in Florida, but canker overrides any other consideration. If and when citrus canker is eliminated from Florida, replanting of these crops on a commercial scale will likely occur.

Jackfruit

There was little input for this species, but it was noted that green shield scale is a problem in the nursery, and snow scale (Pinnaspis strachani) is a problem in field grown trees, both on the trunk and fruit. There are also multiple soft-spot fungi that cause the tree to dieback quickly if they are not pruned out. The biology needs to be studied for both of these problems and efficacious control measures determined and registered.

Summary

As evidenced by comments recorded from meeting members, many of the causative organisms which are pests on tropical fruit are unidentified. Similarly, the pathogens or predators of these pests are also largely unknown. Pest management in these fruit groves is occurring naturally (but undocumented) in many cases. However, certain pests can occasionally (and significantly) affect the production of some topical fruit crops (e.g. sugar apple, "Mauritius" lychee). Overarching areas of investigation for the tropical fruits in general include: investigations on the biology of numerous scale, mite, and other production-limiting or quality-affecting insects; identification and biology of a number of fruit, leaf, and root diseases; development of IPM programs for certain insect pests; and disease and crop phenology models for disease control. There are approximately 1,000 tropical fruit operations in Florida and the industry is worth an estimated $170 million annually to the economy of Florida. The industry employs 3,000 to 4,000 people, and helps support numerous ancillary industries (e.g. farm supply companies, packinghouses). The crops grown are of high value and serve to meet the diverse market demands of the region's many ethnic groups.

Tropical Fruit PMSP List of Attendees

Tropical Fruit Growers/Nurseries

- **Beth Archinal**
- **Bob Benam**, Mother Nature's Nursery
- **Ray Carlyle**
- **Marc Ellenby**, LNB Groves
- **Stuart Kester**
- **Richard Lyons** Lyons & Smith Groves
- **Harry Miller**
- **Reed Olszack**
- **Diego Rodriguez**

- **Stewart Swanson**, Brooks Tropicals
- **Eugenio Tiaz**, Retiro, Inc.
- **Erik Tietig**, Pine Island Nursery

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