

Intercropping of citrus and guava for management of huanglongbing?



A meeting was held during December 2006 in Japan (Japanese International Research Center for Agricultural Sciences, Ishigaki, Okinawa-den, Japan

Vietnamese, Australian, and Japanese researchers reported that an interplanting of citrus and guava negated infestations of Asian citrus psyllid on citrus and, consequently, incidence of citrus greening disease (huanglongbing).

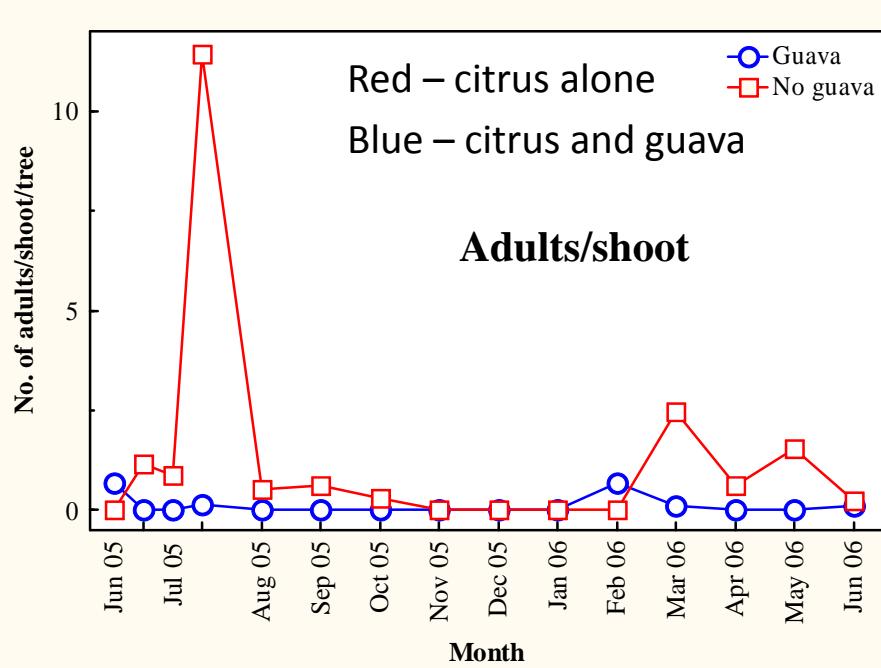
They relayed that there are a number of such interplantings in Vietnam but that the effects of guava against psyllids had gone unnoticed.



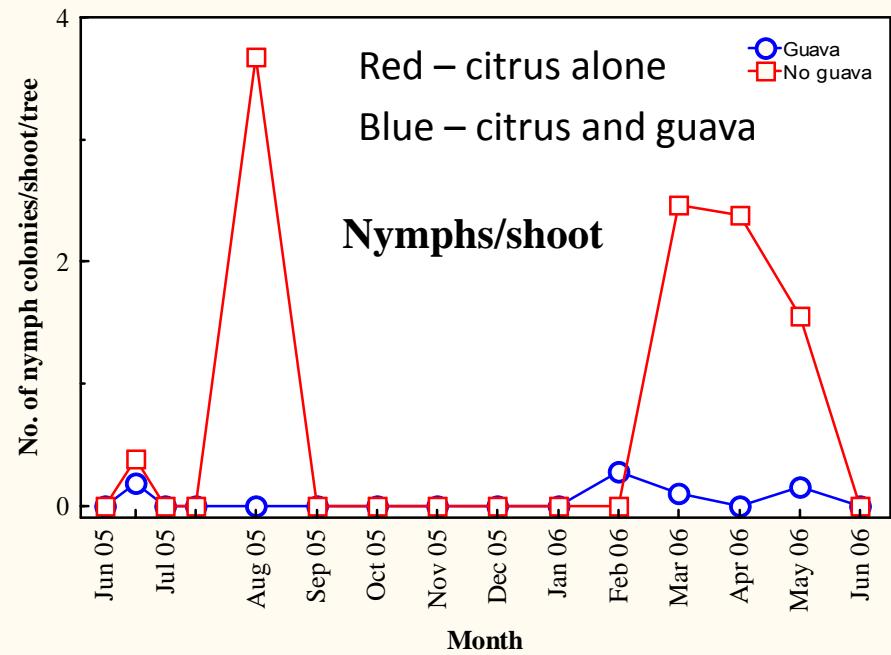
Effect of Citrus/Guava Interplanting on Psyllid Density

One plot of citrus interplanted, one plot of citrus alone, 1 km apart.

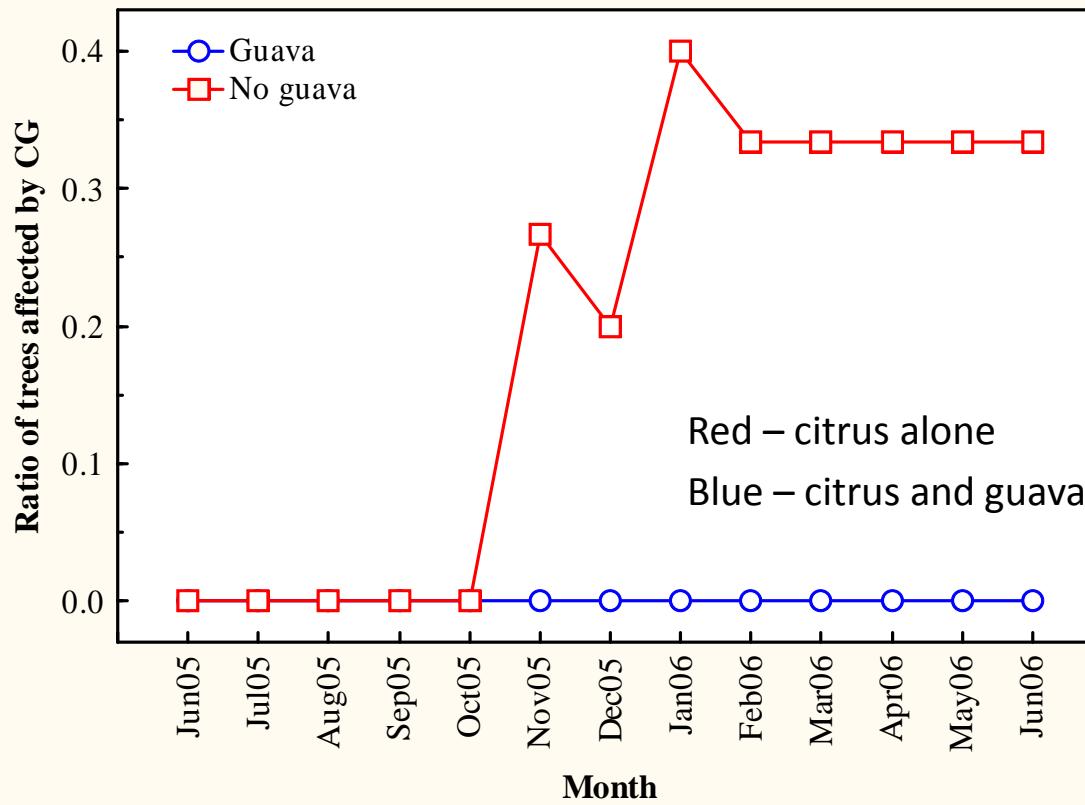
Lower adult psyllid densities



Lower nymph densities



Disease Incidence (%) HLB



- In Guava-Citrus interplanted orchard no occurrence of HLB
- In Citrus Monoculture orchard Increase of HLB after 5 months
- Anecdotal Observations in Vietnam:
 - Most orchards die out within 2-3 years
 - In other places in South Vietnam where they practice guava interplanting, farmers report 15-yr old orchards with little HLB

Reasons that the presence of guava in a citrus grove negated infestations of the psyllid and disease incidence are unclear.

Speculate that there may be volatiles associated with guava that interfere with the psyllid's ability to find and infest citrus, or that repel psyllids.

In choice tests, adult psyllids preferred not to settle on leaves treated with extracts of guava leaves (hexane, acetone). The researchers speculated that terpenoids present in guava were responsible for repellency.



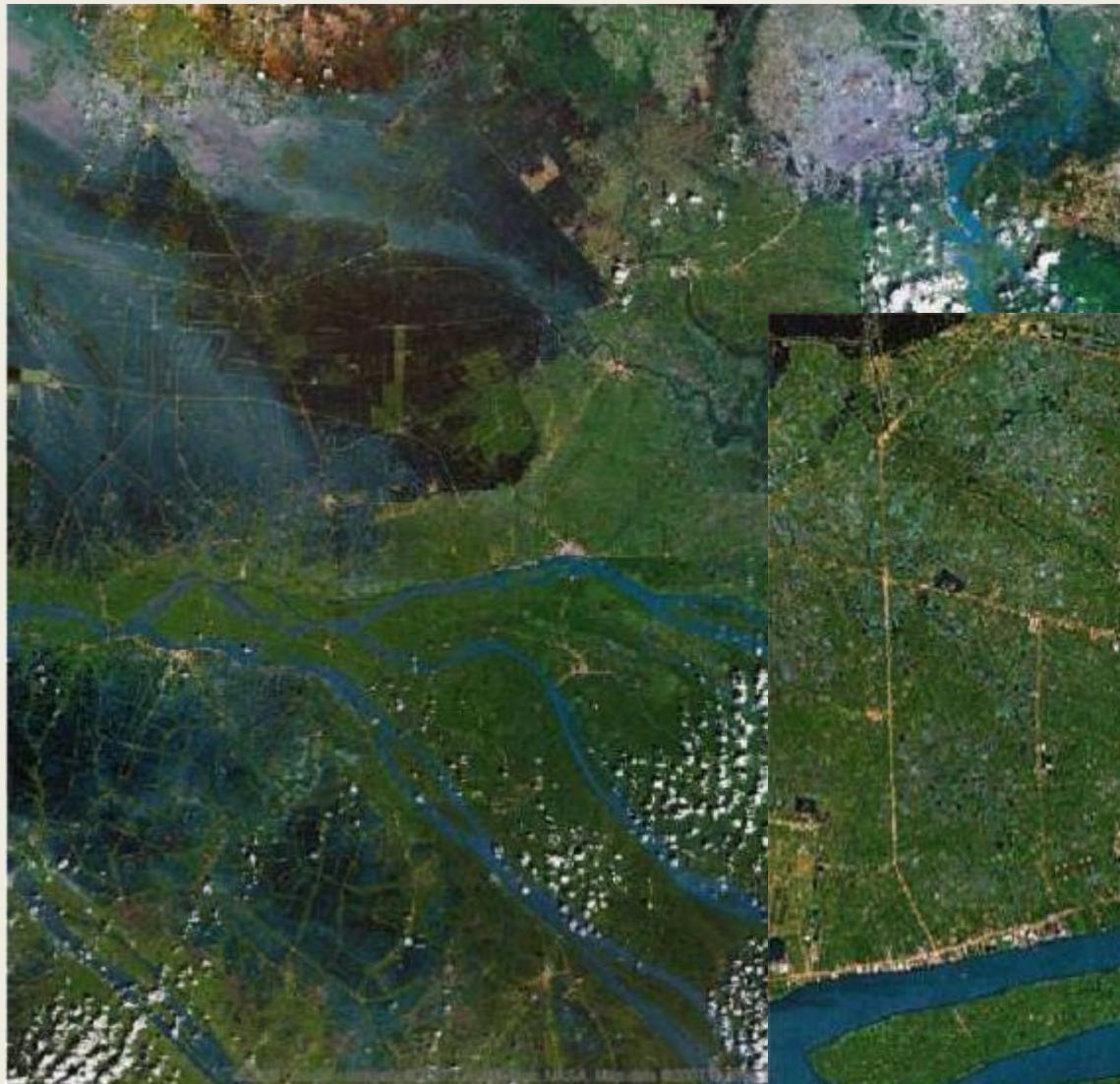
USDA-ARS along with three Florida Citrus Industry Representatives visited South Vietnam during April 23 – 27, 2007, to see interplantings of citrus and guava.





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Mekong Delta and My Tho



- Mekong Delta is at about 9° north of equator.
- North and South Vietnam are separated at about 16° . North Vietnam climate more like Florida, South Vietnam is hotter.

Hosts:
Dr. Nguyen Minh Chau
Director, Southern Fruit Research Institute (SOFRI)
Dr. Katsuya Ichinose (JIRCAS - Entomologist)

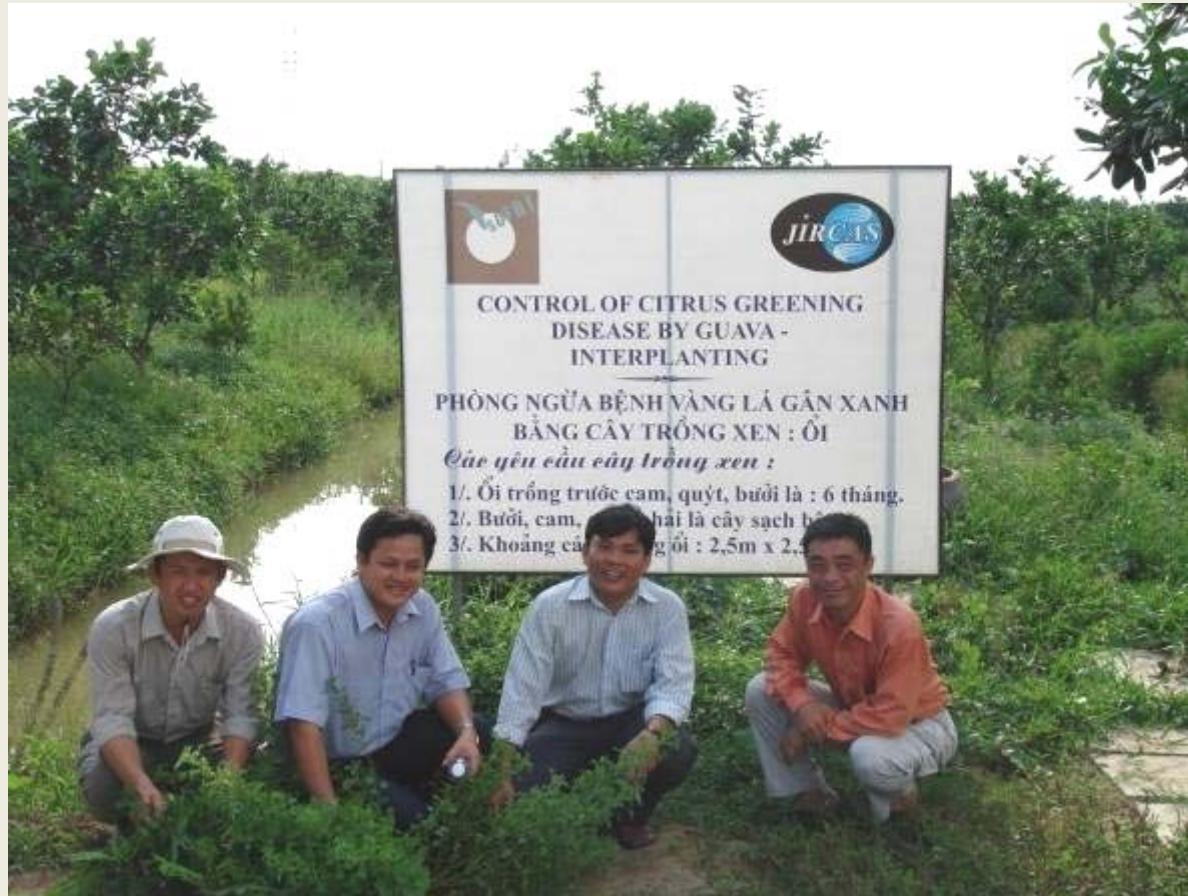


Vietnam Scientists:

Dr. Nguyen Van Hoa (Head, SOFRI Plant Protection Division, Plant Pathologist)

Mr. Le Quoc Dien, Entomologist

Mr. Do Hong Tuan, Entomologist



Dr. Andrew Beattie
(Entomologist,
University of Western
Sydney)



Citrus production in South Vietnam is considerably different than in Florida.

Most farms in Mekong Delta area are in the order of 0.5 ha with a tree of spacing of 2.5 m and row spacing of 2.5 m.



In most of the interplantings of citrus and guava, equal numbers of citrus and guava trees are planted with a tree of spacing of 2.5 m and row spacing of 2.5 m. No heavy equipment is used.









Lime (with HLB) foreground, white guava left, pummelo taller in back



White guava fruits



Site 1: Original study plots, not replicated.

-King Mandarin interplanted with guava versus monoculture of King Mandarin

-**INTERPLANT** situation – **NO PSYLLIDS** found on the citrus trees, 10% infection after 2.5 yr

-**Monoculture** situation – 75% citrus trees infected after 2.5 yr, diseased citrus have now been replaced with guava

Site 2: king mandarin **INTERPLANTED** with guava, citrus and guava were 7 years old. - The guava was much taller than the citrus, 9 to 12 ft tall guava versus 8 to 10 ft tall citrus.

- Had recently removed guava to increase citrus production because citrus was bringing more money than guava.

-**COULD NOT FIND PSYLLIDS**

Site 3: A **MONOCULTURE** of citrus, one group of trees 3 yr old and one group 6 yr old

- **MANY PSYLLIDS** observed in these trees

Site 4: Young pummelo/guava **INTERPLANTED**.

- **NO PSYLLIDS** could be found on citrus, disease incidence low

Site 5: An **INTERPLANTED** plot of 1.5 year old guava and pummelo.

- **NO PSYLLIDS** found, but some leafminers were observed on the citrus.

- Yellow sticky cards (8.5 x 11 inches) but no psyllids on these cards.

Site 6: A **monoculture** of pummelo, 1.5 years old

- Little flush present. Did not find any psyllids.
- Disease present

Site 7: Lime interplanted with guava and lime planted alone, 3 years old.

- **Many psyllids** in the **monoculture** plot.
- **NO PSYLLIDS** in the **INTERPLANTED** plot.

Site 8: 3-year-old **INTERPLANTING** of King Mandarin with white guava bordered by a row of melaleuca.

- Some disease present, estimated 20% trees infected after 3 years
- Leafminer observed, but **NO PSYLLIDS**
- Some signs of old damage by psyllids to leaves

Site 9: 10-year-old **INTERPLANTING** of King mandarin and white guava.

- Trees looked healthy for the most part, some HLB infection observed
- We **COULD NOT FIND PSYLLIDS**.

Site 10: 15-year-old **INTERPLANTING** of King Mandarin and white guava trees.

- Guava was very tall.
- A low percentage of trees infected by HLB.
- We **COULD NOT FIND PSYLLIDS**

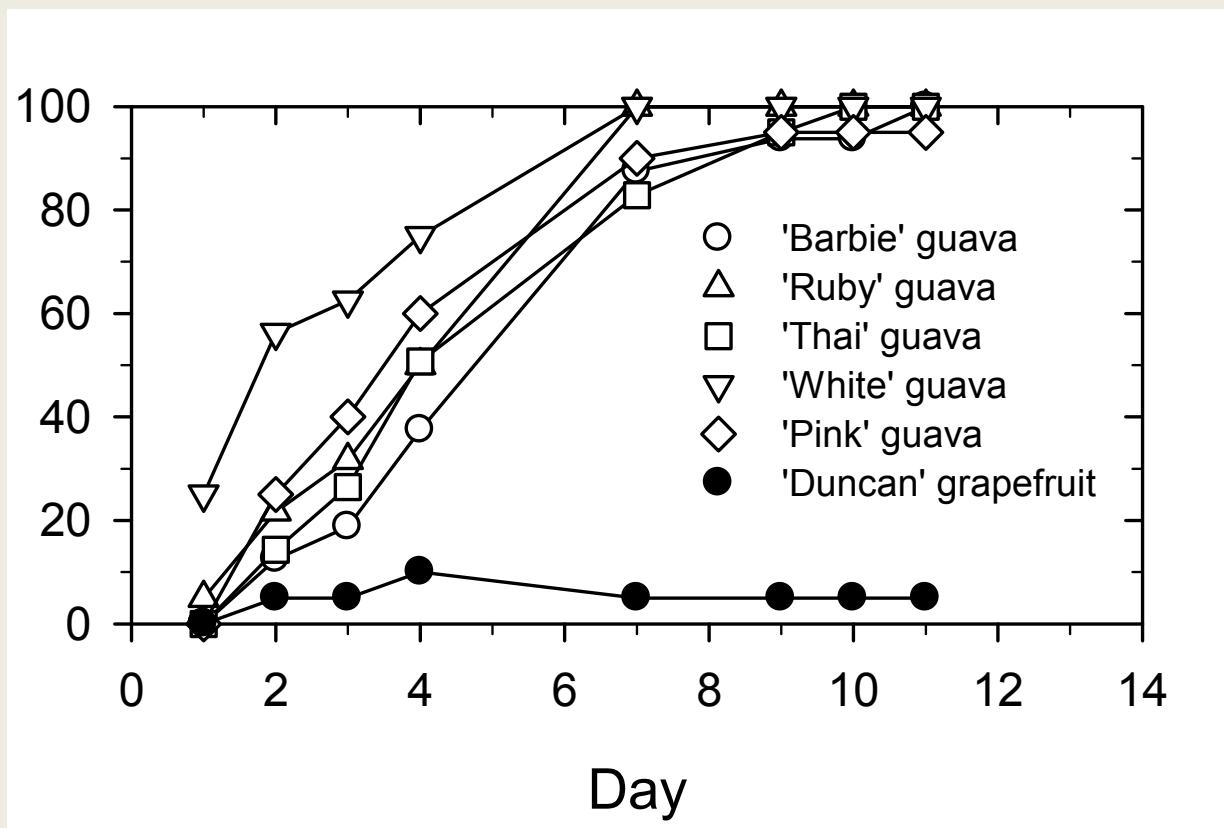
After returning from Vietnam, we initiated greenhouse studies.

No-Choice experiments. Adult longevity on different types of guava versus citrus versus cotton versus tomato (cotton and tomato as non-citrus, neutral plant species).

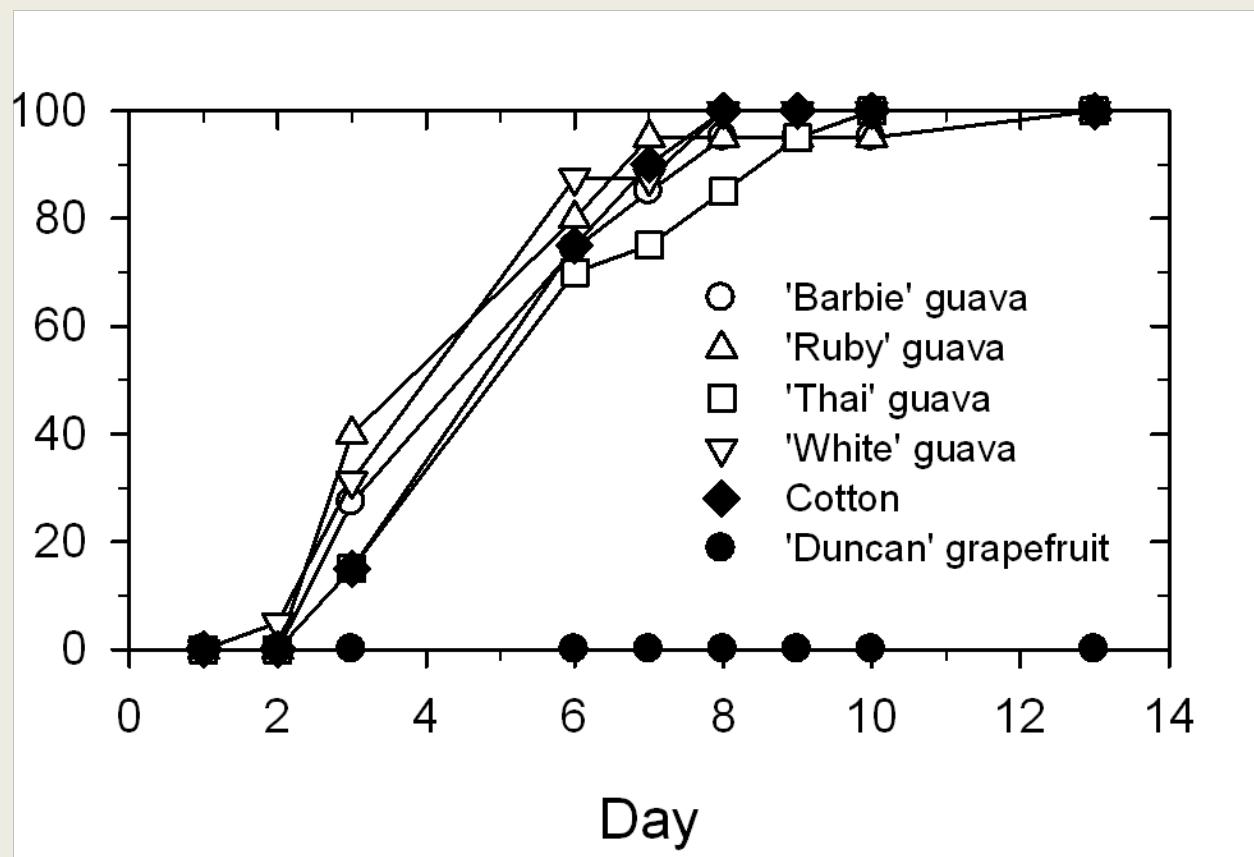
Guava types: White seedless, Thai white, Barbie Pink, Ruby Supreme, and Pink Oval



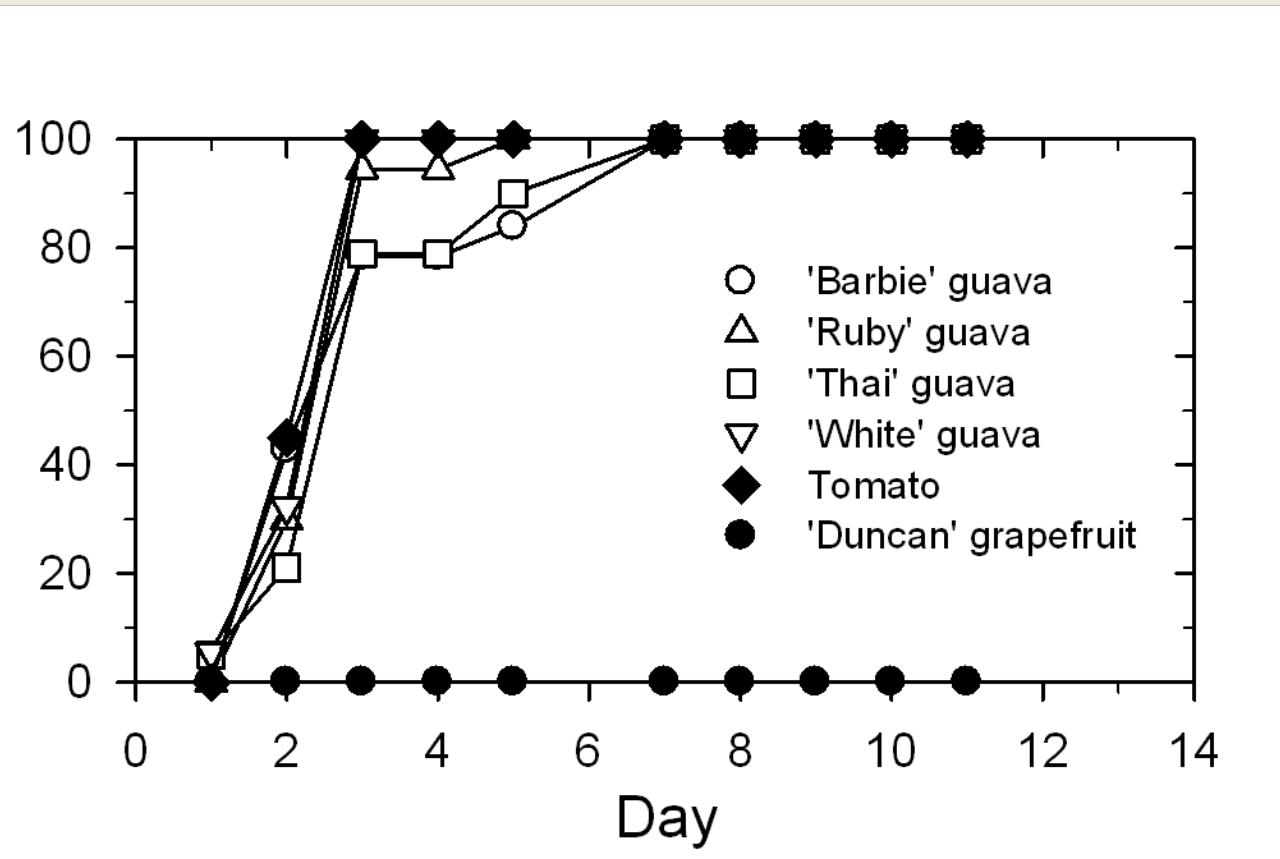
Experiment 1 - Percent mortality in a no-choice study



Experiment 2 - Percent mortality in a no-choice study

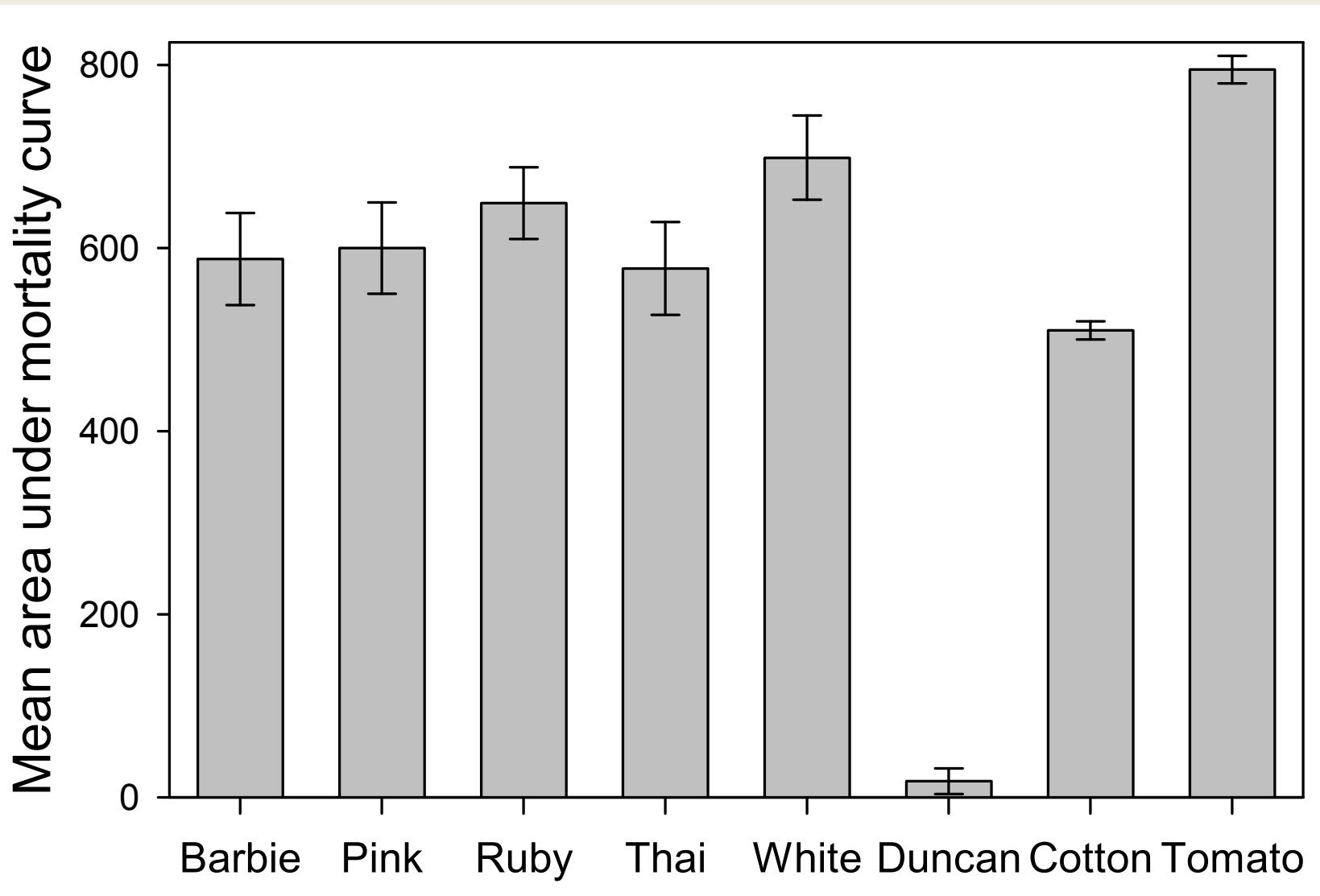


Experiment 3 - Percent mortality in a no-choice study



Average area under curve analysis

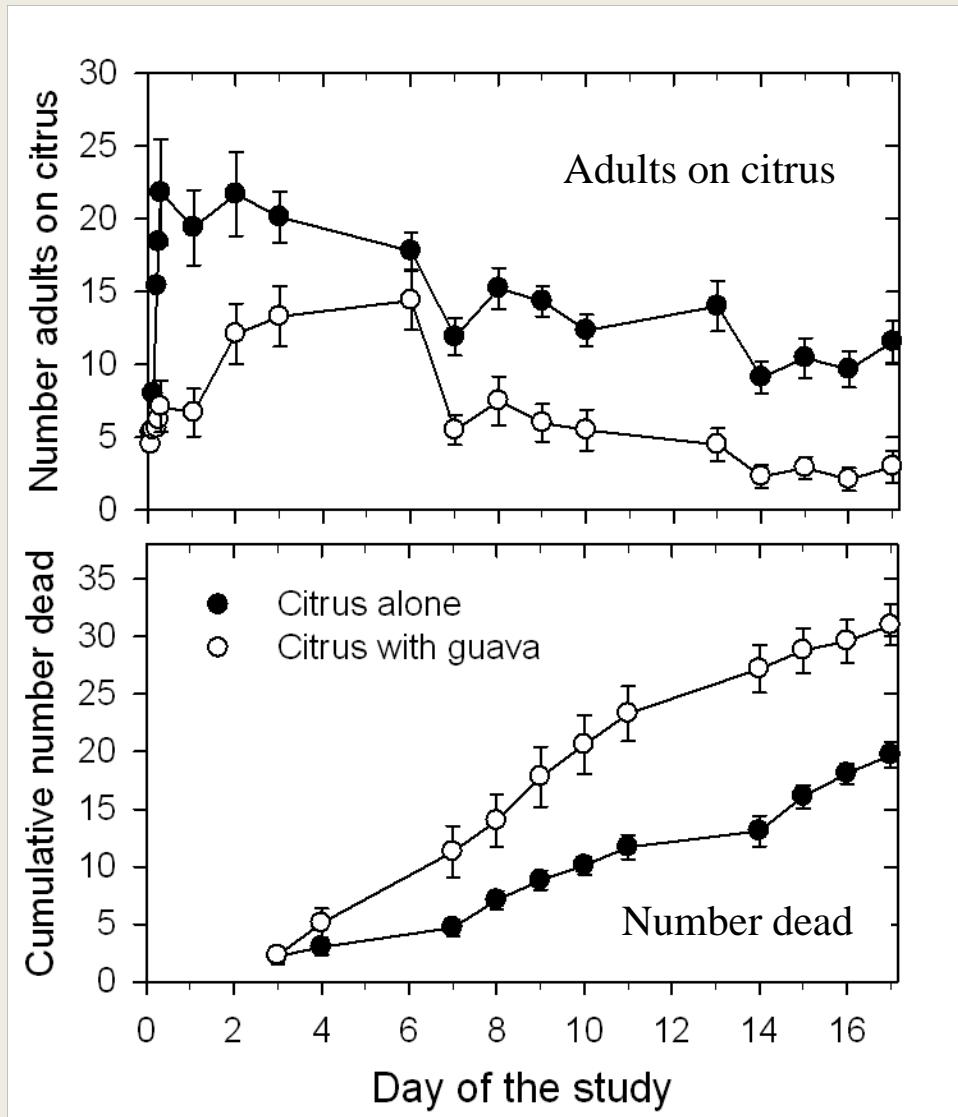
Over all three experiments, percentage mortality of adult psyllids in a no-choice test, 5 different guava types vs citrus vs cotton vs tomato.



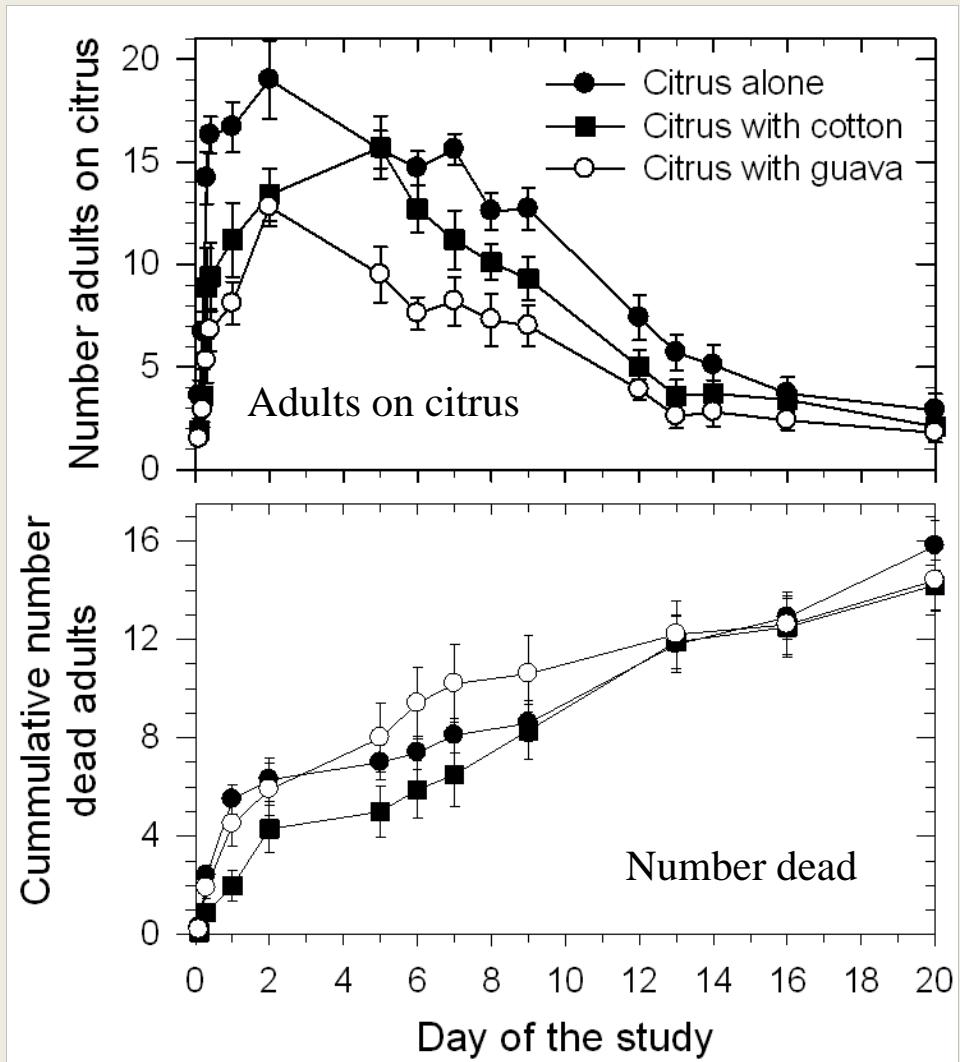
Choice experiments. Adult settling behavior and longevity in cages with citrus alone, citrus with guava, and citrus with cotton.



Number of adults on citrus and death of adult psyllids over time – Experiment 1



Number of adults on citrus and death of adult psyllids over time – Experiment 2



- **Summary of greenhouse studies**
- **Survival of adult psyllids confined to guava was reduced. However, survival of adults was also reduced when they were confined to cotton or tomato.**
- **Adult psyllids introduced into cages generally moved to citrus faster when citrus was alone than when citrus was with either guava or cotton**
- **Greater numbers of adults were consistently observed on citrus over time in cages with just citrus. This may have been in part due to differences in total plant surface areas in cages with citrus alone or citrus with another plant.**
- **In one study, decreased numbers of adults on citrus caged with guava was attributed to the presence of guava.**
- **Mortality rates of adults was increased in cages containing both citrus and guava in one study but not another.**

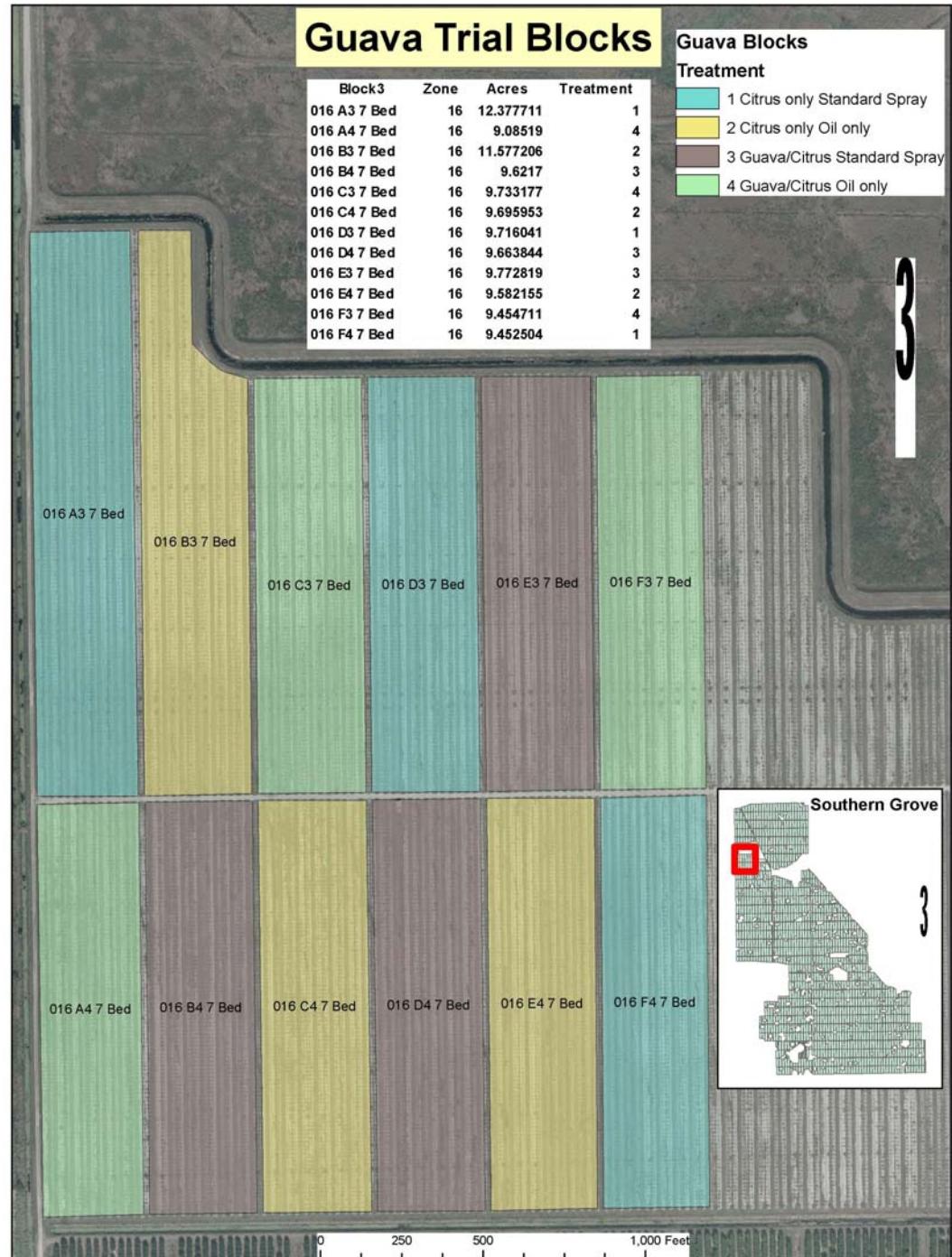
- While significant reductions in infestations of adults sometimes occurred in cages containing both citrus and guava, the levels of reduction were less dramatic than anticipated.
- No evidence of any acute negative effect. Over saturation of guava volatiles in cages?
- Verifying the Vietnamese guava effect will be dependent on field studies.
- Large scale, replicated experiments have been initiated with Consolidated Citrus and Southern Gardens Citrus.
- Planting densities used in Vietnam may play a role in the guava effect against psyllids. A high planting density experiment is being initiated by USDA in Fort Pierce.

Southern Gardens Test

4 treatments, 3 reps

~10 acres per plot

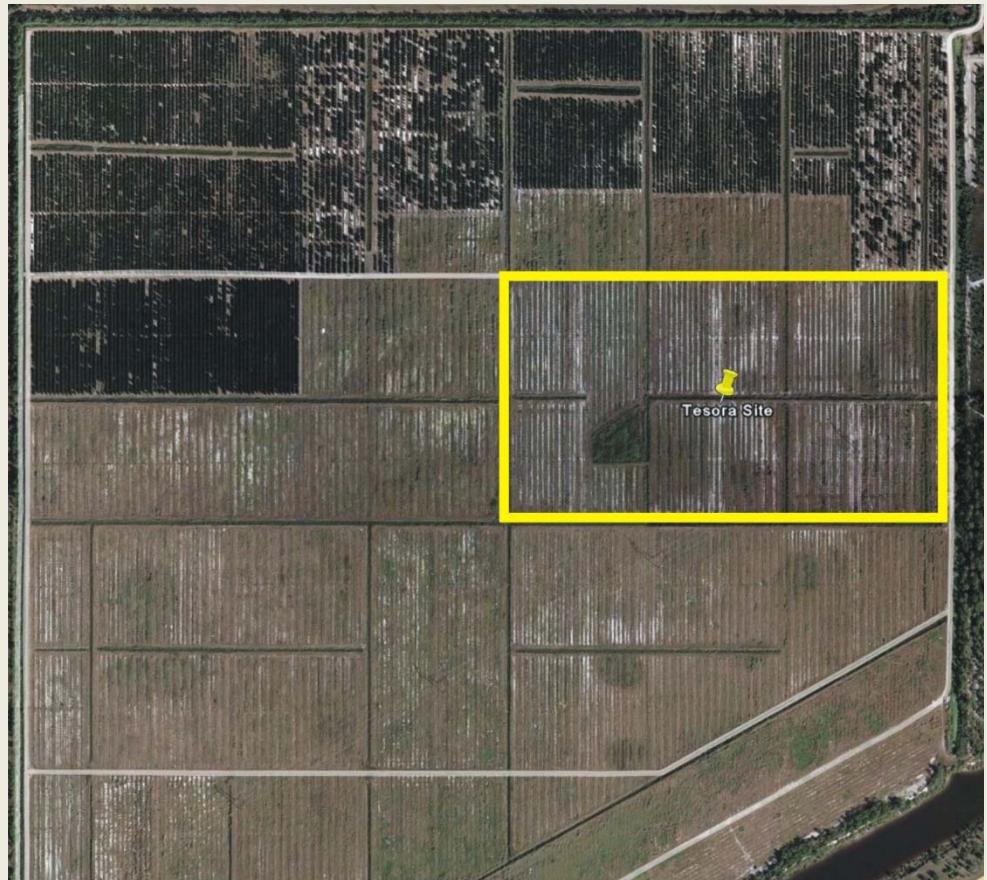
1. Citrus alone with standard spray program
2. Citrus alone, only oil sprays
3. Citrus with guava, standard spray program
4. Citrus with guava, only oil sprays



Consolidated Citrus Test

**2 plantings, each about
50 acres in size**

- 1. Citrus alone with
standard spray program**
- 2. Citrus with guava,
standard spray program**



USDA-ARS High density planting test

8 ft row spacing, 5 ft tree spacing

2 treatments

1. Citrus alone (3 plots)
2. Citrus with guava (3 plots of white guava, 1 plot pink guava)



294 published guava volatiles

ethyl acetate	strawberry guava
ethanol	strawberry guava
α -pinene	strawberry guava
myrcene	strawberry guava
limonene	strawberry guava
ethyl hexanoate	strawberry guava
(Z)- β -ocimene	strawberry guava
(E)- β -ocimene	strawberry guava
terpinolene	strawberry guava
1-hexanol	strawberry guava
(Z)-3-hexenol	strawberry guava
ethyl octanoate	strawberry guava
(E)- β -caryophyllene	strawberry guava
ethyl decanoate	strawberry guava
α -humulene	strawberry guava
α -terpineol	strawberry guava
δ -cadinene	strawberry guava
β -caryophyllene epoxide	strawberry guava
δ -cadinol	strawberry guava
α -cadinol	strawberry guava
ar-himachalene	strawberry guava
tetradecanoic acid	strawberry guava
hexadecanoic acid	strawberry guava
ethyl butyrate	pineapple guava
(E)-2-hexenal	pineapple guava
(Z)-3-hexenol	pineapple guava
(E)-2-heptenal	pineapple guava
3-octanone	pineapple guava
3-octanol	pineapple guava
ethyl hexanoate	pineapple guava
(Z)-3-hexenyl acetate	pineapple guava
methyl benzoate	pineapple guava
linalool	pineapple guava
ethyl benzoate	pineapple guava
2-undecanone	pineapple guava
methyl-4-methoxybenzoate	pineapple guava
α -cubebene	pineapple guava
α -copaene	pineapple guava
B-bourbonene	pineapple guava
β -cubebene	pineapple guava
β -elemene	pineapple guava
longifolene	pineapple guava
α -gurjunene	pineapple guava
β -caryophyllene	pineapple guava
humulene	pineapple guava
alloaromadendrene	pineapple guava
δ -muurolene	pineapple guava
germacrene D	pineapple guava
β -selinene	pineapple guava

ledene	pineapple guava
bicyclogermacrene	pineapple guava
α -farnesene	pineapple guava
calamenene	pineapple guava
δ -cadinene	pineapple guava
(Z)-3-hexenyl benzoate	pineapple guava
palustrol (tentative)	pineapple guava
2-heptyl benzoate	pineapple guava
globulol	pineapple guava
viridiflorol	pineapple guava
ledol	pineapple guava
spathulenol (tentative)	pineapple guava
flavone	pineapple guava
ethanol	Brazilian fruit & juice
1,2-propanediol	Brazilian fruit & juice
1-hexanol	Brazilian fruit & juice
3-hexen-1-ol	Brazilian fruit & juice
neodihydrocarveol	Brazilian fruit & juice
benzyl alcohol	Brazilian fruit & juice
benzoic acid	Brazilian fruit & juice
hexanoic acid ethyl ester	Brazilian fruit & juice
benzoic acid ethyl ester	Brazilian fruit & juice
acetic acid hexyl ester	Brazilian fruit & juice
butanoic acid methyl ester	Brazilian fruit & juice
butanoic acid hexyl ester	Brazilian fruit & juice
butanoic acid 3-hexenyl ester	Brazilian fruit & juice
hexanoic acid-3-hexenyl ester	Brazilian fruit & juice
3-phenyl propenoic acid methyl ester	Brazilian fruit & juice
benzoic acid ethyl ester	Brazilian fruit & juice
benzoic acid octyl ester	Brazilian fruit & juice
cyclohexane	Brazilian fruit & juice
α -terpinene	Brazilian fruit & juice
longiborn-9-eno, beta-sesquifelandreno	Brazilian fruit & juice
2-pentyl-furane	Brazilian fruit & juice
β -ocimene	Brazilian fruit & juice
γ -selinene	Brazilian fruit & juice
α -bisabolene	Brazilian fruit & juice
β -bisabolene	Brazilian fruit & juice
α -bergamotene	Brazilian fruit & juice
cis-cariofilene	Brazilian fruit & juice
β -himachelene	Brazilian fruit & juice
δ -elemene	Brazilian fruit & juice
2-methoxy-2-heptane	Brazilian fruit & juice
limonene	Brazilian fruit & juice
1,3,6-octatriene	Brazilian fruit & juice
1-methyl-cyclopentene	Brazilian fruit & juice
naphthalene	Brazilian fruit & juice
γ -terpinene	Brazilian fruit & juice
alo-aromadendreno	Brazilian fruit & juice

α -humulene	Brazilian fruit & juice
aromadendrene	Brazilian fruit & juice
cyclohexene	Brazilian fruit & juice
benzene	Brazilian fruit & juice
acetic acid 2-propen-1-ol ester	Brazilian fruit & juice
acetic acid 1-butanol ester	Brazilian fruit & juice
2-octil-cyclopropaneoctanal	Brazilian fruit & juice
acetaldehyde	Florida Guava fruit
ethyl acetate	P. guajava fruit aq. Essence
2-methyl-1-propanol	P. guajava fruit aq. Essence
1-butanol	P. guajava fruit aq. Essence
2-pentanone	P. guajava fruit aq. Essence
1-penten-3-ol	P. guajava fruit aq. Essence
methanethiol	Florida Guava fruit
ethyl isobutyrate	P. guajava fruit
acetic acid	P. guajava fruit aq. Essence
ethyl propanoate	P. guajava fruit aq. Essence
2-hydroxy-2-heptanone	P. guajava fruit aq. Essence
isopropyl acetate	P. guajava fruit aq. Essence
methyl butyrate	P. guajava fruit aq. Essence
2-methyl-1-butanol	P. guajava fruit aq. Essence
2-methyl-1-butanol	P. guajava fruit aq. Essence
isobutyl acetate	P. guajava fruit aq. Essence
pentanol	P. guajava fruit aq. Essence
(Z)-2-penten-1-ol	P. guajava fruit aq. Essence
ethyl butyrate	P. guajava fruit aq. Essence
ethyl butanoate	Guava pulp
(Z)-3-hexenol	Guava pulp
hexanal + ethyl butanoate	Florida Guava fruit
butyl acetate	Florida Guava fruit
1-hexanol	Psidium guajava leaf
1-hexenol	Guava pulp
butanoic acid	Florida Guava fruit
butyric acid	Florida Guava fruit
furfural	P. guajava fruit aq. Essence
(Z)-3-hexen-1-ol	P. guajava fruit aq. Essence
(E)-2-hexenal	white guava fruit
ethyl (E)-2-butenoate	P. guajava fruit aq. Essence
(Z)-3-hexenal	white guava fruit
(E)-2-hexenal	P. guajava fruit aq. Essence
3-(Z)-hexenol	Florida Guava fruit
hexanol	P. guajava fruit aq. Essence
2-methyl-3-furanthiol	Florida Guava fruit
methylbutyric acid	Florida Guava fruit
α -pinene	Guava pulp
γ -butyrolactone	P. guajava fruit aq. Essence
2,4-hexadienal	Florida Guava fruit
ethyl hexanoate	Guava pulp
1 R- α -pinene	Guava pulp
methyl hexanoate	P. guajava fruit aq. Essence

Electroantennogram (EAG) studies



- 1. Air puff
- 2. Linalool puff
- 3. Cis-3-hexen-1-ol puff
- 4. Citronellal puff
- 5. Citrus macrophylla flush extract in hexane puff
- 6. Air puff
- 7. White guava fruit liquid extract in hexane puff
- 8. Citronellal puff
- 9. Linalool puff



Saigon (Ho Chi Minh City) Central Market Fruit Stand

