A Perspective of Research on HLB and its Vector in the United States

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ACP – Asian citrus psyllid

HLB – huanglongbing (citrus greening disease)

ACP was first found in the United States (Florida) during 1998, but HLB wasn't found in Florida until 2005

Although HLB has been known in the United States for five years, progress in finding solutions to the disease has lagged.

The 1998 discovery of ACP in the United States prompted a relatively small number of immediate but uncoordinated research efforts during the late 1990s and early 2000s.

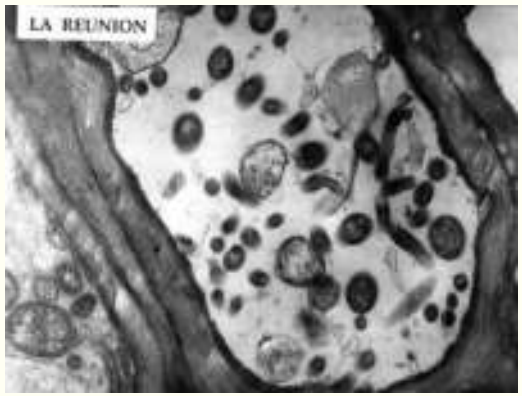
Some assessments were made on ACP biology and biological control, and a classical biological control program was initiated which resulted in the establishment of one parasitoid, *Tamarixia radiata*.

This initial pulse of research on ACP in Florida was followed by a period of time when little research attention was directed toward ACP.

The 2005 discovery of HLB in Florida catapulted a surge of research by USDA-ARS and the University of Florida.

The Florida Citrus Industry responded to the HLB crisis by increasing Florida Department of Citrus funds for HLB research.

The Citrus Industry pressed USDA-ARS in Washington for increased research on HLB, not only by ARS scientists in Florida but also by ARS scientists across the nation



As more monies became available for the fight against HLB, the need increased to identify and prioritize research projects for funding.

These needs were magnified by the invasion of ACP into California and Arizona.

Five major efforts in the USA have been made to identify and prioritize research needs related to ACP and HLB:

1. 2nd International Canker and Huanglongbing Research Workshop held in Orlando, Florida (November 2005), scientists worked together to identify and prioritize research needed on ACP and HLB
2. USDA-ARS held an internal agency meeting to identify and prioritize research on ACP and HLB (April 2008).
3. The National Academy of Sciences (National Research Council) was invited by the Florida Department of Citrus to hold a workshop to identify HLB research priorities, evaluate research proposals, and develop a strategic research HLB plan for the Florida Citrus Industry.
4. International Conference on HLB (December 2008) in Orlando – 427 conference attendees from around the world participated in identifying and prioritizing research projects
5. Citrus Health Research Forum in Denver, Colorado (June 2010) to identify and prioritize research on ACP and HLB on a national level

The outcomes of these organized USA efforts to identify and prioritize research projects on ACP and HLB were similar and can be summarized:

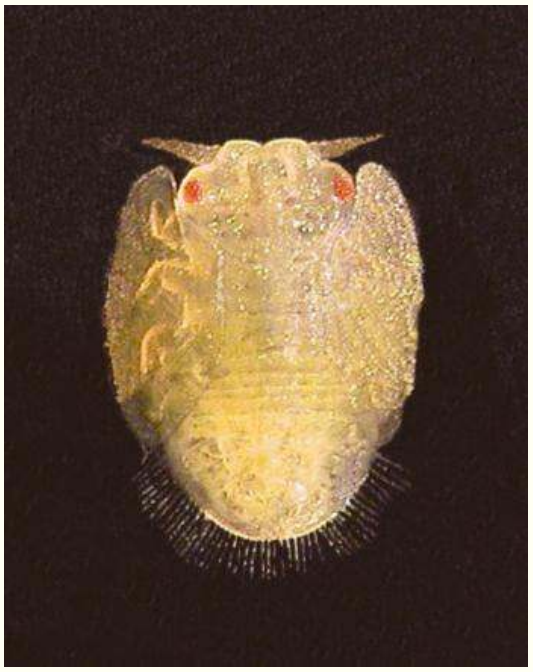
- Culture *Ca.* Liberibacter asiaticus
- Develop better, faster diagnostic tests for the pathogen
- Increase our understanding of disease epidemiology
- Develop antibiotics and therapeutics for HLB control in diseased trees
- Discover new tactics for managing ACP
- Increase our understanding of vector-pathogen interactions
- Identify transmission barriers to the pathogen in individual ACP
- Develop better detection and sampling methods for ACP
- Increase the efficacy of biological control of ACP
- Assess the influence of HLB on citrus juice quality
- Determine differences among citrus cultivars with respect to disease susceptibility
- Develop methods of genetically transforming citrus including mature trees
- Design plant management strategies to reduce ACP infestations and HLB infections.

The National Research Council's 2010 report recommended the following short- and short-to-intermediate-term research priorities:

- Improve insecticide-based management of the Asian citrus psyllid
- Support searches for biomarkers that may be exploited to detect HLB-infected citrus
- Establish citrus orchard test plots for evaluation of new scouting and therapeutic methods
- Accelerate the sequencing, assembly, annotation and exploitation of a sweet orange genome to provide a powerful tool for all future citrus improvement research
- Support development of HLB model systems
- Exploit the *Ca*. Liberibacter asiaticus sequence for new strategies of HLB mitigation
- Support research aimed at developing alternative psyllid management strategies
- Support small-scale studies on the feasibility of alternative horticultural systems suited to endemic HLB
- Support demonstration of RNA interference (RNAi) effects for possible psyllid suppression
- Develop *in-vitro* culture techniques for *Ca.* Liberibacter asiaticus to facilitate experimental manipulation of the bacterium for insights into gene function
- Sequence, assemble and annotate the psyllid genome to provide a basis for new approaches to psyllid management

The National Research Council also made long-term research recommendations:

- Support development of transgenic HLB-resistant and ACP-resistant citrus
- Support development and testing of bactericides, therapeutics or SAR activators
- Support analysis of ACP behavior, ACP-plant interactions and ecology to enhance the knowledge base available for new ACP management strategies
- Explore possible control strategies based on releases of modified psyllid males



The Florida Citrus Research and Development Foundation, California Citrus Board, and other funding agencies are targeting high-priority research projects. Many of the high priority research projects are being funded.
Projects being funded include:

(1) developing better diagnostic tests for the disease bacterium;
(2) culturing the bacterium in pure form;
(3) sequencing/annotation of a sweet orange genome;
(4) sequencing the ACP genome;
(5) refining insecticide programs for psyllid control;
(6) research is being conducted on alternative ACP management strategies including RNA interference, disruption of the psyllid feeding process via blocking formation of salivary sheaths, and biological control;
(7) efforts to establish transgenic HLB-resistant citrus cultivars are underway (antimicrobial peptides); and
(8) therapeutics/SAR activators/nutritional programs for sustaining tree productivity are being investigated.

Area-Wide Management of ACP and HLB

None of the generated lists of research project needs and priorities have directly addressed area-wide ACP management, but other invasive insect pests have been successfully managed using area-wide strategies.

Interest has evolved among Florida citrus growers in coordinated, area-wide ACP management.

This interest has occurred because empirical observations and published reports indicate that psyllid flight activity regularly occurs over relatively long distances.

Currently, the primary tactic of an area-wide management program for ACP would be insecticide sprays to commercial citrus, perhaps one or two coordinated spray during the winter each applied to large areas in a small window of time

Research to develop area-wide ACP control programs is needed.

Area-Wide Management of ACP and HLB

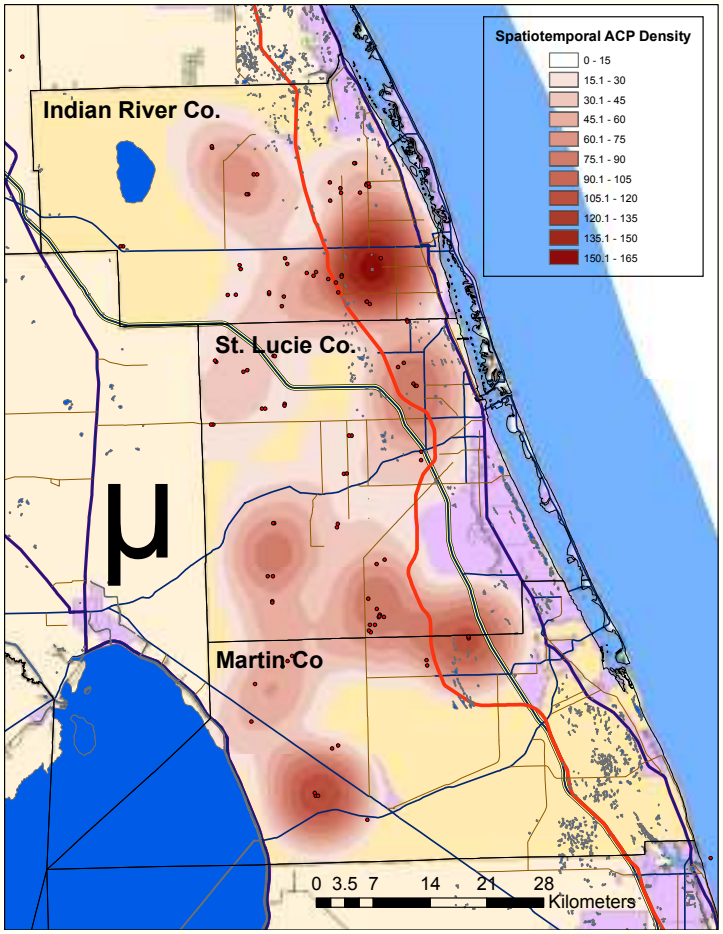
An investigation of area-wide psyllid population levels was conducted in the Indian River Citrus area of Florida.

A large number of citrus blocks (geo-referenced) scattered across three counties was sampled weekly for a year.

Spatiotemporal plots of psyllid levels across the three counties revealed that there were some areas which tended to have higher populations of psyllids than others.

On a month-to-month basis, hot spots of psyllid infestations were sometimes identified.

In an area-wide management ACP program, such information could trigger spot sprays or releases of biological control agents.



ACP/HLB Regulatory Issues in the USA

Efforts to identify and prioritize research projects on ACP and HLB have largely pertained to keeping existing citrus orchards alive and productive.

However, USDA-APHIS-PPQ and other regulatory agencies have been confronted with questions deserving research attention.

For example, a shipment of limes from Mexico into Texas recently occurred in which some adult psyllids were found.

Also, the movement of citrus leaves, specifically the leaves of *Citrus hystryx* ('kaffir lime', used as a spice), has proven to be a pathway for the spread of ACP and HLB.

The potential spread of ACP and HLB in such shipments is of concern especially when fruit or leaves are harvested and shipped from an area under quarantine or known to be HLB infected.

Research is needed to identify harvesting and shipping procedures that can be used to ensure live psyllids are not transported. Such procedures need to be practical and affordable.

ACP and HLB Research Funding in the USA

Florida Citrus Industry and California Citrus Research Board have been primary sources of funds.

Funds from the Florida Citrus Industry

•For the past 20 years, growers have been assessed a tax (based on yield) and funds collected have been used for marketing citrus and for scientific research

•Usually about US $6 million annually has been directed toward research

•After the discovery of HLB in Florida, grower funds for citrus research were increased to US $16 million annually.

•Currently about US $10.7 million of federal and state funds are spent on ACP and HLB research nationwide.

•Therefore a total of about US $26.7 million is being spent on ACP and HLB annually.

•Additional federal funds for research are being obtained through NIFA, Specialty Crop Initiative Grants, and Specialty Crop Block Grants.

ACP and HLB Research Progress in USA

Papers published in peer-reviewed journals serve as a track record of research progress.

The University of Florida maintains an up-to-date worldwide database of publications on HLB (http://swfrec.ifas.ufl.edu/hlb/database/searches.htm).

Publications on ACP and HLB:
An average of 10 publications per year during 2000-2004
An average of 49 publications per year during 2005-2009.
The large increase was largely due to contributions to the literature by researchers in the Americas.

The Florida Citrus Production Research Advisory Committee maintains a database of progress reports associated with research grants funded by the Florida Citrus Industry (http://research.fcprac.com/reports/).

THANK YOU FOR YOUR TIME AND ATTENTION!