Component II: Protection of Agricultural and Horticultural Crops

2b. Citrus (U.S. Value 2007: $2.9 billion)

***Problem Statement*:** The principal commercial citrus species (oranges, grapefruit, lemons, and tangerines) do not produce maximum yields due to the following pests:

- Citrus Greening, Transmitted by the Asian Citrus Psyllid (Florida, all citrus species)
- Citrus Canker and the Increase in its Transmission by the Asian Citrus Leafminer (Florida and Texas, all citrus species)
- *Phytophthora*, Transmitted by the *Diaprepes* Root Weevil (Florida and Texas, all citrus species)
- Tristeza Virus and its Efficient Vector, the Brown Citrus Aphid (Florida and Texas, all citrus species)
- Citrus Rust Mite (Florida and Texas, all citrus species)
- Pink Hibiscus Mealybug (Florida, all citrus species)
- Glassy-Winged Sharpshooter (all citrus producing areas, all citrus species)
- Weeds that Compete with Citrus Tree Resources, Harbor Insect and Rodent Pests, Increase Cold Damage, Increase Disease Pressure, Impede Harvest, Interfere with Low Volume Irrigation Systems, and Intercept Soil-Applied Chemicals (all citrus producing areas, all citrus species)
- A Major Issue is the Loss of Biological Control Agents Due to the Use of Pesticides to Control Vectors of Pathogens (Florida and Texas, all citrus species)
- A Second Issue is Glyphosate-Resistant and Other Herbicide-Resistant Weed Biotypes (all citrus producing areas, all citrus species)

***Research Needs*:**

1. **Asian Citrus Psyllid and Citrus Greening Disease**

   Importance: The Asian citrus psyllid vectors a bacterium that causes a disease known as citrus greening, considered the world's worst citrus disease. The vector and disease are new to Florida, and are jeopardizing Florida citrus with the potential to jeopardize the entire U.S. citrus industry. The vector has spread to Puerto Rico and Texas, and reports indicating that the putative pathogen is present in Texas. Recently, the psyllid and greening disease were found in Louisiana. The psyllid has not yet been found in Arizona or California, but it has been spreading rapidly across Mexico over the last several years and will likely reach these two states. Since 2005 when the disease was first found in Florida, hundreds of thousands of citrus trees have been removed from groves in an effort to reduce disease inoculum.

Research Gaps: In order to save the citrus industry, immediate research is required to develop efficient pesticide treatments against the Asian citrus psyllid. To the extent possible, these methods should avoid damaging current biological control and IPM systems that successfully control other pests. Efficient monitoring methods for the psyllid and diagnostics for the pathogen would facilitate the targeting of control methods. Longer-term research objectives should focus on developing techniques for eliminating the disease regionally or controlling it sustainably. In addition to the gaps that can be addressed with current ARS resources, customers have identified the need for improved chemical controls for the vector, including approaches that minimize application rates through development of low volume, electrostatic methods.

Actions: ARS will:

Monitoring

- Improve sampling and monitoring methods for the vector.
- Apply improved sampling and monitoring techniques to determine host preference, particularly in dooryards where numerous host species and cultivars may serve as refuge habitats for the vector.

Control, Interference with Vector Olfaction

- Discover volatile attractants (pheromones and host-plant volatiles), and plant repellents or confusants that can be used for interfering with vector mating and host-location.
- Determining mating behavior, acoustic signaling, visual and olfactory orientation, and spatial dynamics (movement).

Control, Biological

- Explore for new biological control agents, devise methods for culturing, introducing, and conserving biological control agents, determine genetics of known biological control agents, and screen for microbial pathogens of the psyllid.
- Develop biological control strategies tailored to control the vector in residential areas, abandoned orchards, and other vector refuge areas where chemical controls may not be appropriate.

Control, Interference with Vector Biology

- Determine the role of endosymbionts in the biology and reproduction of the insect.
- Determine the mechanisms of pathogen acquisition and transmission.
- Understand the role of specific genes in important biological phenomena, i.e., development, feeding, reproduction, and pathogen transmission associated with greening expression.

Control, Insect Resistant Citrus

- Use conventional and molecular methods to develop citrus varieties resistant to psyllids (and the pathogen).

Control, Chemical

- Develop chemical control strategies that are acceptable in dooryards and residential areas.

2. Citrus Leafminer and Citrus Canker Disease

Importance: Injury to citrus leaves by the citrus leafminer is known to exacerbate citrus canker disease. Canker is an important disease of citrus due to the negative effects it has on tree productivity and yield. Perhaps more importantly, citrus canker is now endemic to the state of Florida which has severely reduced the State's citrus export market. This is because many potential customers live in regions where canker is currently not present, and trade embargoes have been established against the Florida fresh fruit market. It is also a problem in Texas. Bacteriologists are seeking improved methods for managing the disease, including: windbreaks, novel chemical control sprays, and even transgenic solutions.

Research Gaps: Urgent solutions to the canker problem are needed. This includes determining the extent to which the citrus leafminer exacerbates the incidence of canker, as well as methods for controlling the leafminer. In the short-term, control will likely be dependent on insecticides during the summer, although increased pesticide use for this purpose is undesirable. Concurrently, there is a need to initiate development of long-term, sustainable approaches to leafminer management.

Actions: ARS will:

Monitoring

- Improve sampling and monitoring methods for citrus leafminer and citrus canker disease.
- Investigate optimal pheromone component blends for attracting and monitoring leafminers in traps.

Damage Assessment

- Assess the quantitative relationship between leafminer damage to citrus and both the incidence and severity of citrus canker.

Control, Interference with Leafminer Olfaction

- Discover volatile attractants (pheromones and host-plant volatiles) and plant repellents or confusants that can be used to interfere with leafminer mating and host-location.

- Determine optimal pheromone component blends for mating disruption in order to reduce the spread of citrus canker.
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3. ***Diaprepes* Root Weevil**

Importance: The *Diaprepes* root weevil is an important pest of citrus and some ornamental plants in Florida and has spread to Texas and California. For a number of years this weevil was considered the most important invasive insect pest of Florida citrus (until the arrival of the Asian citrus psyllid and citrus greening disease). Progress has been made in managing *Diaprepes* root weevil in citrus and ornamentals in Florida. Biological control agents have been imported and successfully established but only in extreme southern areas of the state. Citrus germplasm with some resistance (tolerance) to feeding by larvae of the weevil has been identified. However, affordable, environmentally sound strategies for this pest are still lacking. Sampling methods have been developed for the adult stage of the weevil, but these are for the most part mediocre methods.

Research Gaps: Solutions to the Diaprepes problem in citrus are urgently needed. The most promising and sustainable strategies identified came about through advances in our knowledge of the chemical ecology of the weevil and the development of citrus with plant resistance to the weevil.

Actions: ARS will:

Attractants

- Discover plant kairomones, weevil pheromones and non-host plant allomones that can be used to attract, repel, or confuse *Diaprepes* root weevil.
- Identify and synthesize promising semiochemicals.

Monitoring

- Improve sampling and monitoring methods for the weevil using traps baited with an attractant.

Control, Interference with Weevil Olfaction

- Develop methods of using attractants for interfering with *Diaprepes* mating and host-location.

Control, Host Plant Resistance

- Develop a transgenic citrus rootstock with resistance to *Diaprepes* root weevil. (Fort Pierce, Florida: Shatters, Hall, Lapointe)

***Anticipated Products*:**

- Increased knowledge of pest biology, ecology, behavior, genetics, and biological control agents, and of plant traits conferring pest resistance.

- Discovery, characterization, and synthesis of insect attractants, repellents and confusants.
- New biological control agents.
- Increased knowledge of the genomics and basic biology and ecology of biological control agents.
- Information on specific genes and gene-products involved in the replication of plant disease organisms in vector insects.
- Information on endosymbionts associated with subtropical insect pests.
- Identification of plant traits that might be used to develop pest-resistant plants.
- Development of plants with pest resistance.
- Novel methods of reducing the impact of subtropical insect pests of citrus, vegetables and ornamental plants.
- Information on trap crops as potential tools for pest management.
- Improved pest sampling and detection methods.
- Mating disruption.

***Potential Benefits (Outcomes)*:**

- Strategies for improved IPM of subtropical insect pests.
- Reductions in crop losses to insect pests of citrus and the plant diseases they transmit.
- Reductions in expenditures to manage insect pests.
- IPM tactics that are ecologically sound.

***USDA ARS Resources*:**

- Beneficial Insects Research Unit, Weslaco, Texas
- Subtropical Insects Research Unit, Fort Pierce, Florida