U.S. Department of Agriculture
Center for Plant Health, Science and Technology
Huanglongbing Technical Working Group
August 6 – 8, 2008
New Orleans, LA

Introduction

Huanglongbing (HLB, Citrus greening), is the most serious disease of citrus known. In general, it has devastated citrus production in nearly all regions of world where it is known to occur. With few exceptions, attempts to successfully manage the disease have met only limited success or have been unsuccessful except when all hosts are eradicated as well. The biology of the pathosystem leads experts to conclude that eradication of the disease or the insect vector, the Asian citrus psyllid (ACP), *Diaphorina citri*, is impossible once established. There are no known sources of host plant resistance, and even extremely aggressive vector control (e.g., between 26 and 52 insecticide treatments per year in Brazil) has only succeeded in incrementally slowing the spread of disease. The distribution and apparent spread of HLB in Florida is stunning. In citrus groves owned by one company, disease progress went from an initial seven symptomatic trees to more than 350,000 infected trees over a 2-year period. One conservative economic analysis indicates that the commercial industry in Florida may pass below the threshold of economic viability in less than seven years (Norbert, unpublished). In a single word, the outlook is bleak.

Other than in Florida and two parishes in Louisiana, the pathogen ("*Candidatus* Liberibacter asiaticus", Ca. Las) and disease has not been confirmed to be established elsewhere in the continental U.S. ACP was first identified in Florida in 1998, had spread to 31 counties by 2000, and is now distributed throughout much of the entire state (51 counties). It was identified in Texas in 2001 and while ACP appears to occur at infestation levels lower than have been observed in FL, it is present in most Gulf Coast counties in Texas and in the Lower Rio Grande Valley (LRGV) (35 of 254 counties). In May of 2008, ACP was confirmed in Louisiana. In June of 2008, APHIS PPQ confirmed the presence of HLB in a residential lime tree in Orleans Parish and a sweet orange tree on a residential property in Washington Parish on September 5, 2008. Surveys for ACP and HLB continue in Louisiana. In August of 2008, ACP was detected in Alabama, Georgia, Mississippi, and S. Carolina. Finally, ACP is known to occur in Mexico, and was confirmed in Tijuana, MX, in July of 2008 and the City of San Diego, California on September 2, 2008 by the USDA ARS Systematic Entomology Laboratory. Clearly, the commercial citrus industries in all parts of the US are at risk.

The HLB Technical Working Group (TWG) was asked to provide scientifically-based recommendations to decision makers for the at-risk regions and industries to try to best prepare for the arrival and establishment of the ACP where it is not yet present, or establishment and spread of HLB where the ACP is currently established. (The members of this TWG are listed in appendix I).

Several facts and consensus judgements, some previously mentioned, are key considerations for formulation of the recommendations:

- There is no precedent and no reason to believe that the ACP, once established in an area with appropriate hosts and environmental conditions, can be eradicated. To our knowledge, this has not been accomplished anywhere else in the world where citrus production remained intact.
- Once introduced into a region where the vector is present, HLB has not been eradicated from any location in the world.
- Early detection of HLB is extremely improbable. The disease can be latent in a host for months or years, resulting in history being viewed once symptoms are visible. Asymptomatic trees cannot be identified in visual surveys and are unlikely to be efficiently detected even by PCR testing. Additionally, psyllids can acquire HLB pathogens from asymptomatic trees.
- Disease control is difficult due to the latent period.
- The symptoms are non-specific and easily confused with other diseases, mechanical damage or nutritional deficiencies.
- The bacteria are unequally distributed within the host which makes it difficult to adequately sample portions of the plant to readily detect the disease.
- There are currently no commercially useful sources of host plant resistance.
- Biology of the psyllid makes surveying for early infestations of low populations of psyllids extremely difficult. Both timing and frequency of visual surveys for early stages of psyllid infestations are important due to the timing of flushes of new growth on host material.
- Psyllid testing by molecular diagnostics is not an optimal method for determination of HLB in a region where it is endemic. If psyllids test negative for Ca. Las do not demonstrate that a region is free of HLB. However, positive results do provide information for more targeted surveys, as they have been shown to demonstrate a reservoir of infection in a region particularly in areas where they have been recently detected. Example, the recent ACP find in Algiers, Louisiana led to detection of HLB immediately afterward. Psyllids must be collected and tested in a timely manner. In some instances in Florida, Ca. Las positive psyllids were detected many months before infected trees were detected.

Nevertheless, citrus production may remain viable or be able to withstand the introduction of HLB if aggressive and concerted actions are taken immediately in States not yet affected by HLB, or, as is the case in Louisiana, with apparently low levels of disease and vector populations or Texas with only the vector. The TWG carefully examined the current situation in Florida and retrospectively what set of actions based on today's scientific understanding might have been taken to lessen or mitigate the spread and possibly the incidence of the disease. This retrospective attempts to take the best scientific information and the opinions of subject matter experts into account. As a result of these discussions, strategies emerged that could potentially allow citrus production to continue for several more years in regions outside of Florida as compared to scenarios of no action or less aggressive actions being taken.

The TWG defined a fully successful strategy as one where the disease is not detectable following surveys – a state that is likely not possible if the disease is introduced into a region with an established vector population. Ideally, with deployment of host plant resistance in conjunction with effective intensive vector population suppression, the disease progress curve could be "flattened". However, to our knowledge, host plant resistance is not available. Alternatively, and less desirable, are strategies which move the disease progress curve further down the time line, but would not affect the slope of the curve. Theoretically, this would sustain commercial production of citrus and allow time for the development of improved detection and control/management tools. These sorts of approaches are more effective in annual crops where the crop is destroyed at the end of a production cycle. Nevertheless, a strategy could be considered successful if viable commercial citrus production continues. Under these strategies, intermittent disease expression could be tolerated if it can be suppressed to a manageable or threshold level.

A major challenge for the implementation of the strategies described below is homeowner cooperation in survey and control/management, including possible tree removal. It is important to include and/or increase outreach and public education efforts as soon as possible in all potentially affected regions. The public can and should be utilized as surveyors for vectors and disease. Outreach and public education would also serve to increase awareness of the impact of host plant movement from affected areas. Psyllid populations are higher in urban areas and abandoned groves due to lack of structured insect management such as exists in commercial production. Political boundaries can also affect the implementation and success of a strategy in dealing effectively with vectors and the disease. If possible, it would be of greater benefit to determine and establish regions for application of controls/strategies, regardless of political boundaries.

The technical/scientific discussions focused primarily on the pathosystem and tenets of vectored plant pathogens. These discussions resulted in a series of recommendations which were grouped into options from most restrictive to less restrictive. The restrictiveness of the options is proportional to probability of successfully managing the disease. The options or combinations of recommendations under different options could be utilized by decision makers when faced with positive confirmations of either the vector and/or the pathogen.

Recommendations:

Elsewhere in the world, once the disease is introduced with an established vector population, eradication has never succeeded, and management of the disease has met with only occasional success in circumstances not comparable to N. America.

In areas devastated by HLB, in the absence of any new disease management technology, Option A followed (in time) by Option B may be, from a technical standpoint, the most effective approach to disease management in discrete regions.

Option A – Both ACP and HLB have become established in a region) This is the most aggressive strategy developed, with the goal of reducing vector to very low levels, and eliminating the pathogen by removing the host. This will interrupt the disease transmission cycle, thereby effecting control of the disease regionally.

- Complete host eradication (Bellis et al., 2005) within 15 miles to perhaps up to as much as a 150 mile radius of a HLB positive detection (including all residential citrus and all ornamental hosts)
- Aggressive area-wide vector control to limit or prevent spread of vectors
- Commercial citrus and dooryard citrus and other rutaceaeous host plant owners must be in complete agreement and compliance with the above actions (buy-in from stakeholders is of paramount importance regardless of the options put into effect)

"The TWG recognizes Option A is not likely a practical solution, as complete eradication of the host in a commercial/urban interface could prove difficult and is therefore not practicable or likely to succeed." Also, the current host list should not be considered comprehensive or complete. However, it points to the realities of HLB. A fallow period would interrupt the disease, particularly in commercial citrus and nursery stock. Indeed, the distance that would effectively interrupt the disease is not known, hence the 15-150 mile radius. It also needs to be noted that here and elsewhere, the TWG recommends "aggressive vector control", but recognizes that in itself is a complex topic and may require a separate TWG meeting.

Option B is an aggressive strategy intended for regions with low incidence of HLB and low infestation levels of the ACP. Although this option will have significant impact on private and commercial citrus, this option will allow the opportunity to return to a disease free status in as short time period as possible. Due to disease latency, this option will be most effective in areas where the ACP has been recently established rather than in areas where ACP has been established for long periods of time.

Option B (ACP is widespread, but HLB is detected at low levels)
This strategy assumes comprehensive semi-annual ACP detection surveys conducted by state and or federal personnel. (See New Pest Response Guidelines for Citrus Greening for information on ACP/HLB detection surveys).

- Outreach/education—stakeholder buy-in ASAP. *This is an essential and common theme for all options. There are many potential elements, including training of Master Gardeners, media blitzes, etc.*
- Area-wide Insect control/suppression (in nurseries, commercial production groves, and backyard trees?)
    - Periodic compliance monitoring by State/Fed components
- Tree Removal; Buffer Zones
    - Remove all dooryard citrus, *Murraya* spp. and other non-citrus hosts within 24 km (15 miles) of a positive detection

- HLB positive grove tree destruction as soon as disease is found
- Periodic compliance monitoring by State/Federal components
- (TX specific) at first detection of HLB, remove all citrus, *Murraya* spp. and other non-citrus hosts within a radius of 1 km (3280 ft) and contiguous citrus (a situation that may be unique to the LRGV, remove contiguous block/grove, not split by roads, within defined distance). (This is based on two pathosystem generations for movement, 1640 feet per cycle as per Koizumi et al., 1997).
- If disease is present for a number of consecutive years for a period of time to be determined, the grove should be removed.
- Moratorium on grove replanting for a period of time to be determined
- Destroy abandoned groves/orchards (groves which do not meet minimum standards of management). A regulatory definition of "abandoned groves" is necessary.

- Protecting the Citrus Nursery Industry (especially for out-of-state markets), Clean Stock, Sanitation
  - Approved insect-resistant structures are paramount (double entrance, positive air pressure)
  - Regulate movement and production of citrus nursery stock (including Rutaceae ornamentals)
    - Enact regulations to ensure clean citrus nursery stock is produced in approved structures
      - All new and certified clean nursery stock must be placed within an approved (highly insect resistant) structure
      - Ban wholesale and retail sales of existing citrus nursery stock for two years (including ornamentals)
        - Hold in an approved (highly insect resistant) structure
        - Separate from all new and clean material for two years on a regional level
      - Eliminate retail commerce of *Murraya* spp. and other non-citrus hosts and citrus completely
      - Institute registration and traceability of all citrus nursery stock (clean plant network)

Option C (disease present, but at low levels)
This strategy assumes comprehensive semi-annual detection surveys. (See New Pest Response Guidelines for Citrus Greening for information on ACP/HLB detection surveys).

- Outreach/education—stakeholder buy-in, ASAP
- Commercial/Nursery insect control/suppression
  - Periodic compliance monitoring by State/Federal components
- Tree Removal; Buffer Zones
  - Positive tree destruction as soon as disease is found in tree(s)

- At 5% or more threshold of HLB incidence (either single incidence or cumulative % over time), remove grove (chronic disease situation)
- All commercial production must be at least 0.5 km distance away from residential citrus

- Protecting the Citrus Nursery Industry, Clean Stock, Sanitation
  Approved insect-resistant structures are paramount (double entrance, positive air pressure).
  - Regulate movement and production of citrus nursery stock (including ornamentals)
    - Enact regulation to ensure clean citrus nursery stock in an approved structure
      - Move all nursery stock into an approved structure
      - Hold and test all nursery stock two times a year for two years
      - Test all scion and seed source trees two times a year
      - Destroy everything in the containment area if any plant tests are HLB positive
  - Institute registration and traceability of citrus (clean plant network)
  - Any plants for sale found to be exposed to *Diaphorina citri*, should be considered as exposed to HLB and should be destroyed
  - Eliminate retail commerce of non-citrus Rutaceae completely
- Destroy abandoned groves/orchards (groves which do not meet minimum standards of management)

Option D (incorporate into above option)
Same as Option C with the following differences:

- Regulate retail commerce of Rutaceae (not eliminate), including cut flower and culinary ACP and HLB host plant industries
- Disallow movement of existing HLB/ACP-exposed citrus nursery stock (instead of holding for two years) out of regulated area
  - Establish a minimum standard for protection
- Provide growers with options dependent on what is found through survey

Survey:
Dr. Tim Gottwald of USDA, ARS, in Ft. Pierce, Florida, shared with the TWG a model for a survey developed in cooperation with University of Cambridge and Rothamsted Research. This model is currently in use in Florida for their citrus multi-pest survey. The TWG recommends the adoption of this system for disease surveys for HLB, particularly after the initial find within a state.

- Biased stochastic model
- Survey methodology irrespective of location
- Model will select survey sites and ranking
- Able to select bias for survey, i.e. certain host species, cultivars
- Divide survey area into regional areas, sections, or larger groupings
- Parameters for fiscal and manpower resources

- Survey can utilize homeowner sites, up to 170 – 180 sites per mile
- Survey timed to maximize disease detection

This model is perhaps only one aspect of an overall survey strategy, and there may be other possibilities that could be considered as well, depending on the situation. As with this model, any survey will not be on the same level of detail as a census (100% survey). It will be difficult to find incidence at a **disease** incidence 1% level or less or the **vector** at low incidence with a high degree of confidence. With an optimum survey, the reliable detection of **disease** under the best of circumstances is less than 90%, which can result in a 10% or greater chance of missing a positive detection, partially due to the latency of the disease.

The Gottwald model can provide a sound resource specific survey based on the inputs related to site specific biases. There may be situations that require very targeted surveys in which other methods could prove to be of greater benefit.

The Florida experience with initial surveys for HLB concentrated on urban areas, focusing on those areas with populations that match demographics from areas of the world where the disease is endemic. In both Louisiana and Florida, the initial detections were in urban areas, and not in commercial groves. The most likely introduction points could be in urban areas.

Additionally, in Florida there is no real difference among host species, except that calamondins may be tolerant to HLB and more difficult to get a positive PCR result. The literature repeats the idea that lemons and limes are not as susceptible. In fact, in Florida, those cultivars appear to have the most dramatic symptoms. HLB in lemon and lime is distinctive and not likely to be confused with other conditions.

An objective of this TWG was to develop options on a regional basis, recognizing that the situations in the SE U.S. are different than in Texas or the SW U.S. Thus, determining which options to implement may be dependent on the region in question.

- **Louisiana (Gulf Coast states)**
  - Psyllids are present
  - HLB exposed
    - Survey, sentinel trees. It is important to understand the extent of infection, which likely will not become apparent until after surveys over the next 6-12 months. This information will influence decisions as to which strategies are most likely to be effective.
  - Enact Option B, followed in time by Option C, or Option D
  - Public education/outreach

- **Texas (Hawaii, Puerto Rico)**
  - Psyllids are present; no indication at this time of direct exposure to HLB
  - Survey for HLB
    - Remove groves if disease is found
    - Enact Option A, followed in time by Option B, or Option C
  - Public education/outreach

- **California, Arizona**
  - Survey for psyllids and diseased plants
  - Preventative measures; nursery stock and budwood in approved structures
  - Public education/outreach
    - Upon find of HLB, follow Louisiana/Gulf Coast plan

Koizumi, Meisaku, Prommintara, M., Linwattana, G., Kaisuwan, T. 1997. Epidemiological Aspects of Citrus Huanglongbing (Greening) Disease in Thailand. Japan Agricultural Research Quarterly, 31, pp. 205-211.

Bellis, Glenn, Hollis, D., Jacobson, S. 2005. Asian citrus psyllid, Diaphorina citri Kuwayama (Hemiptera: Psyllidae), and huanglongbing disease do not exist in the Stapelton Station area of the Northern Territory of Australia. Australian Journal of Entomology, 44, pp. 68-70.

Appendix I

HLB Technical Working Group, New Orleans, LA
August 6-8, 2008

Phil Berger	USDA PPQ CPHST
Russ Bulluck	USDA PPQ CPHST
Pat Gomes	USDA PPQ EDP
Wenbin Li	USDA PPQ CPHST
Phil Mason	USDA PPQ Western Region
John Hartung	USDA ARS, Maryland
Wayne Dixon	Florida Department of Agriculture and Consumer Services, DPI
Susan Halbert	Florida Department of Agriculture and Consumer Services, DPI
Tim Gottwald	USDA ARS, Florida
David Hall	USDA ARS, Florida
Mike Irey	U.S. Sugar Corporation, Florida
John da Graca	Texas A&M University-Kingsville
Mamoudou Setamou	Texas A&M University-Kingsville
Mary Lou Polek	California Department of Food and Agriculture
Natalie Hummel	Louisiana State University Agricultural Center

Observers/Other Participants:

Sherry Sanderson	USDA PPQ Western Region
Tad Hardy	Louisiana Department of Agriculture and Forestry
Craig Roussel	State Plant Regulatory Officer, Louisiana
Bill Spitzer	USDA PPQ State Plant Health Director, Louisiana
Joe Bravata	USDA PPQ Louisiana
Stuart Kuehn	USDA PPQ State Plant Health Director, Texas
Don Ferrin	Louisiana State University Agricultural Center
Greg Parra	USDA PPQ CPHST