National Agricultural Research, Extension, Education, and Economics (NAREEE) Advisory Board

MINUTES OF THE CITRUS DISEASE SUBCOMMITTEE MEETING

December 9-11, 2014
Citrus Research & Education Center, University of Florida
700 Experiment Station Road, Lake Alfred, FL

CONTENTS

Respectfully submitted,

_____	_____	_____
Tom Jerkins	Dr Etienne Rabe	Michele Esch
Chair	Vice Chair	Executive Director

APPROVAL BY ADVISORY BOARD: _____
Date

_____	_____
Initials	Initials
Chair	Executive Director

EXECUTIVE SUMMARY

The Citrus Disease Subcommittee (CDS), a statutory subcommittee of the National Agricultural Research, Extension, Education, and Economics (NAREEE) Advisory Board (hereafter "the Board") met in public session on December 9-11, 2014, in Lake Alfred, Florida.

The main goal of the meeting was to discuss the annual budget, agenda and funding priorities for the Citrus Disease Research and Extension Program (CDRE), part of the National Institute of Food and Agriculture's (NIFA's) Specialty Crop Research Initiative (SCRI). The meeting included a closed session, during which CDS members heard information about the 2014 CDRE grant awards. This information helped to frame the priorities and agenda for the 2015 program. Notes from the closed session are only available to the NAREEE Advisory Board Office.

It was agreed that the Requests for Applications (RFAs) for Fiscal Year (FY) 2014 were too broad in setting research priorities, which resulted in wide-ranging proposals without the desired depth on key topics. Therefore it was decided that a more focused set of priorities was needed for the next set of RFAs, and that CDS should provide four items that constitute the highest priorities for the industry as a whole. With consideration of the funding decisions that have been made in FY2014, CDS members agreed on the following:

1) *Agenda*. CDRE funding in FY2015 should continue to focus on HLB.
2) *Budget*. All of the FY2015 budget of $25 million should be obligated during that year.
3) *Priorities*. By a majority vote, a motion was passed that the funding priorities for FY2015 are the following four items, in ranked order:
    1. Chemical and heat therapy systems to kill or suppress bacteria.
    2. Culturing (cultivating) the *CLas* bacterium.
    3. Early detection of the bacterium in host and vector.
    4. Resistant germplasm.

CDS members engaged in a question and answer session with representatives from the Citrus Research and Development Foundation, Inc. (CRDF), California Citrus Research Board (CRB), USDA Agricultural Research Service (ARS), and the Citrus Health Research Program (CHRP) of the USDA Animal and Plant Health Inspection Service (APHIS). This discussion emphasized that research and development around citrus disease needs:

- Better coordination between all the different agencies and programs that provide funding for citrus disease research and development, including federal and state governments, non-profit organizations and private industry; and
- Better communication between those funding sources, current research projects, and the citrus growers / industry.

Particular issues of concern raised during the discussion were:

- *Antimicrobial resistance.* It was noted that the Food and Drug Administration, Centers for Disease Control and other agencies are very sensitive to the issue of antibiotic resistance with respect to human health. It was also noted that the USDA has developed an action plan around the issue of antimicrobial resistance in agriculture. However, the citrus industry is heavily dependent on bactericides to combat HLB, particularly in Florida.

- *Genetic modification.* Concerns were raised about how current consumer perceptions of genetically modified organisms (GMOs) would affect the citrus market if a new GMO or transgenic citrus plant were developed to be resistant to HLB and provide an effective solution. Similarly, concerns were raised about the impact on the organic citrus industry if a GMO product (either a citrus plant or biocontrol method, e.g. a GMO psyllid) were to be mandated. It was noted that each regulatory agency has an operational definition of 'genetically modified' and 'transgenic', but those definitions may differ between agencies.
- *Funding coordination.* It was noted that research on citrus disease is funded by many different entities, at a federal, state and private level, each operating with a different timeline and agenda. It is difficult for scientists to keep track of the various funding opportunities and requirements, and for growers to identify where new developments are coming from. Despite the efforts of MAC, better coordination and communication is needed.

A suggestion was made that CDS expand its work to assume the role of lead coordinator of information about citrus disease research. For example, CDS could organize an annual meeting / forum for researchers on citrus disease to share their work with each other and with growers. It was also suggested that CDS contact CDRE project directors and invite them to present research progress at future CDS meetings, in order to gain more up-to-date information both for reporting back to the citrus industry and for CDS to make more strategic recommendations to the USDA.

CDS members engaged in a discussion about more general aspects of citrus disease research, extension and education as per the committee's mandate. The following items were noted as topics for further discussion and making recommendations to the USDA, in addition to the significant coordination and communication issues described above:

- The exclusion of citrus disease researchers from scientific merit review panels because of conflict of interest concerns – does this limit the ability of reviewers to judge the science?
- If a CDS meeting includes a closed session, CDS members should be trusted with privileged information for the purposes of making necessary recommendations to the USDA.
- Considerable expertise and funding lies within the private sector and some mechanism for accessing that information should be found.
- RFAs should adhere to the priorities set by CDS and press releases about awards should include a statement to indicate stakeholder approval of those priorities.

CDS members heard presentations about current research efforts from representatives of CRDF, CRB, ARS and CHRP. Projects cover the breadth of vector control, reduced pathogen inoculum, and reduced tree susceptibility and injury. High priorities are antimicrobial therapies, expansion of thermal therapy, tolerant rootstocks, biocontrol methods, and RNAi work. Several projects are conducting field trials of integrated pratices. The agencies are all aware of the issues of antimicrobial resistance and pollinator health. As such, they are conducting research on the impacts of pesticide residue and generally considering antimicrobials as a short-term solution until another effective and sustainable strategy is found. The presentations emphasized differences in the citrus industry between Florida and California, and noted that early detection is of high importance in California due to a lack of widespread infection. It was noted that the majority of CRDF projects will expire by July 1, 2015, while HLB-MAC's $21 million appropriation must be obligated by September 30, 2015.

This meeting included a optional tour of current research, laboratories and displays at the University of Florida's Citrus Research and Education Center.

A working group was formed to write a report, including formal recommendations, based on the minutes of this meeting for forwarding to the Secretary of Agriculture.

Resolutions and Recommendations

- CDS developed and approved an agenda, budget and list of four priorities to be provided to NIFA for the development of the CDRE RFA for FY2015.
- Future CDS meetings to discuss recommendations for the CDRE program should not be held without members having prior access to the details of new funding awards.
- CDS should meet twice per year in person and possibly more frequently via conference call.

Action Items

- CDS will develop a report and recommendations based on the minutes of this meeting. This report will be reviewed by the NAREEE Advisory Board and, once approved, forwarded to the Secretary of Agriculture.
- NIFA will provide CDS with information about newly funded projects as soon as possible, including project director, other project personnel, abstract, budget, and contact details.
- Executive Director will schedule a conference call once the CDRE awards are announced.
- The next meeting of CDS will be scheduled for a week after the intended date for awarding the next cycle of grants, to be determined once the RFA is published.

TUESDAY, DECEMBER 9, 2014

PART I: Welcome and Introductions

INTRODUCTION OF MEMBERS AND OTHER ATTENDEES

Tom Jerkins (Chair, Citrus Disease Subcommittee of the NAREEE Advisory Board, hereafter "CDS") called the meeting to order at 1:05 p.m.

Michele Esch (Executive Director, NAREEE Advisory Board, and Designated Federal Officer, CDS) welcomed everyone to the meeting. She reminded attendees that while the majority of the meeting is open to the public, there would be a closed session in the afternoon only for CDS members. All other presentations are open to public inspection in the NAREEE Advisory Board Office.

All of the attending CDS members, other meeting participants and guests introduced themselves. *Note: A list of attending CDS members and other participants for each session of the meeting is provided in Appendix A of this report.*

WELCOMING COMMENTS

Tom Jerkins welcomed everyone to the meeting and noted that the main purpose of the meeting was to think about the next level of research priorities for the Citrus Disease Research and Extension Program (CDRE), part of the National Institute of Food and Agriculture's (NIFA's) Specialty Crop Research Initiative (SCRI).

PART II: Citrus Disease Research Efforts and Activities

INTRODUCTION OF PANEL MEMBERS

Michele Esch introduced each panel member, and noted that the purpose of the presentations was to hear about the current status of citrus disease research across different groups.

PANEL PRESENTATIONS

Dr Harold Browning (Chief Operations Officer, Citrus Research and Development Foundation, Inc. [CRDF]) gave a presentation to the CDS entitled 'HLB Research and Delivery of Solutions, Florida Industry Research Overview'.
Note: *A list of all meeting presentations made to CDS members is provided in Appendix B. These presentations are available on request through the NAREEE Advisory Board Office.*

Browning briefly described the progressive biological impacts of Huanglongbing (HLB) disease and the consequent economic impacts to the citrus industry, which drive the current research needs. He noted that a significant decline in Florida citrus productivity can be seen since HLB became widespread in 2007/2008.

Browning mentioned the different levels of federal funding for citrus disease research, including the CDRE program through SCRI (focused more on medium- to long-term outcomes) and the HLB Multi-Agency Coordination Group (MAC) (focused on short-term solutions and delivery of solutions to growers). He noted that current citrus disease research portfolios cover a breadth of topics from improved vector (Asian Citrus Psyllid, ACP) control, reduced pathogen (bacterium *Candidatus Liberibacter asiaticus*, or *CLas*) inoculum, to reduced tree susceptibility and injury.

CRDF is currently funding 91 projects of length 1-3 years specifically focused on Huanglongbing (HLB) disease, out of a total of 107 projects in the Citrus Advanced Technology Program (CATP) research portfolio of approximately $30 million. However, it was noted that 64 of those projects will expire by July 1, 2015. CRDF also has 36 active projects specific to HLB in the Commercial Product Delivery (CPD) portfolio out of a total of 40 projects, of which 25 will expire by July 1, 2015. It was noted that projects related to antimicrobial therapies are the top priority in the CPD. Other project topics include thermal therapy, tolerant rootstocks and psyllid shield (RNAi) work. The CDRF's short-term research goals are to retain the health of existing trees and provide tools to ensure the success of new plantings, in order to keep the flow of industry alive and build confidence with growers.

Browning noted that *CLas* chemical therapies are aimed at stabilizing or reversing the decline of chronically infected trees and are probably a short-term "band aid" solution, which could be replaced as more durable strategies are proven effective. He also noted that more growers are using thermal therapy, particularly to treat small trees, but it is still unclear how the treatment works. CRDF is currently conducting evaluations of commercially available tools, including field trials of integrated practices – determining the individual impact of each component of a strategy – and Advanced Citrus Production Systems, including consideration of growing under containment. CRDF is working with registrants, the Florida Department of Agriculture and Consumer Services (FDACS) and the EPA to consider expanded use of basal trunk insecticide applications, which are more effective than foliar pesticides. It was noted that research is underway to investigate concerns over pollinator health with regard to insecticides, including honeybees. Browning noted that breeding programs have been in place in California for a long time and now have well established rootstocks. Current work is trying to establish why these rootstocks are tolerant to disease and how robust they might be. CRDF is planning commercial-scale field trial plantings of tolerant rootstocks in the spring of 2015.

Dr MaryLou Polek (Vice President, Science and Technology, California Citrus Research Board [CRB]) gave a presentation to the CDS entitled 'Citrus Research Board'.

Polek emphasized differences in the citrus industry between Florida and California. In particular, the Californian industry relies heavily on exports of high quality table fruit, which makes the issue of non-residual pesticides very important. Despite the ACP being widespread throughout southern California and increasingly in the Central Valley, only one tree in a residential backyard has tested positive for HLB infection to date. California has mandated that any tree found to be infected be removed, and has invested heavily in education and outreach including in residential areas.

Polek noted that much of CRB's research with the HLB pathogen, including pesticide evaluations, has to be conducted in a contained research facility. This provides obstacles to the research program.

CRB has three priorities: (i) early detection, rapid response and eradication of invasive pests; (ii) plant security, including clonal protection and food safety; and (iii) maintaining open and free access to markets. CRB's continuous program is organized into 3 core programs: citrus clonal protection, breeding and evaluation, and pest management. It was noted that CRB programs are funded on an annual basis, with a current annual research budget of $5.5 million, but CRB has received special dispensation to commit funds to 5 projects in partnership with CRDF. CRB also funds one large cooperative project focused on early detection technologies. Polek noted that this ccooperative project is a good way to get scientists to share information and collaboration, but the project coordination requires a lot of time and effort.

CRB is funding 24 projects focused on the *CLas* bacterium. Early detection research is split between the plant host response and pathogen detection. One current project is a longitudinal study looking at the use of digital drop PCR to sample plants both within the contained research facility in California and in production groves in Texas. Other project topics include: early detection using proteomics and secreted proteins (serology), the plant's microbiome, both aboveground and belowground, and a high-risk survey. CRB contracted the Jet Propulsion Laboratory (JPL) to conduct flyovers to map citrus trees in residential areas in the Los Angeles area. However, it was noted that this was not as productive as hoped. CRB is also preserving important commercial varieties in a cryogenic facility in Fort Collins, Colorado.

CRB addresses consumer issues in several ways. The ACP/HLB outreach and education program is funded mainly through the Citrus Pest and Disease Prevention Program. CRB has engaged a public relations firm since 2007 to help with appropriate public messaging, and has hosted a series of grower education seminars. Recently these seminars have focused on genetically modified organisms, and have yielded the insight that growers would prefer to use a genetically modified psyllid than a genetically modified citrus plant.

Polek noted that all CRB-funded researchers are required to write progress reports that appear in the Citrograph magazine.

CRB is currently funding 12 projects on production systems, which include: a breeding and evaluation core program; transformation-based: rapid cycling of plant breeding and micro-propagation of mature citrus; screening of citrus and citrus relatives for tolerance / resistance to HLB; evaluation of non-California varieties; and maintaining citrus export trade partners. It was noted that many of the genetics projects funded by CRB are co-funded by CRDF and based in Florida. CRB has formed an Early Detection Task Force. The Citrus Pest and Disease Prevention Committee (CPDPC) funds an operational program administered by the California Department of Food and Agriculture (CDFA), which conducts surveys and trapping for early detection of ACP infestation and provides treatment on the detection of one or more psyllids. CRB is also funding research to assess the residual quantities of pesticides in nectar and pollen and the exposure levels of honey bees to systemic pesticides. CRB currently funds 15 projects related to disease vectors, including several projects on biological controls, natural predators, pesticide

effects, organic and conventional pesticide evaluations, transgenic RNAi-based psyllid control, disease transmission efficiencies, attractants / attract and kill / repellants, and integrated pest management.

Polek noted that CRB had a research budget of about $2.3 million in 2008-2009 when the first psyllid was detected. This has grown to $5.5 million in 2014-2015, of which 57% ($3.1 million) is devoted to ACP and HLB. All of the funding is provided by citrus growers and federal funding; there is no state research funding.

Polek closed by noting that there is a need for better knowledge mapping and a way for scientists to talk and share progress and ideas. Dedicated research forums provide a good opportunity for scientific discussion and should be supported. Better communication is also needed to avoid duplication of research efforts.

Dr Gail Wisler (National Program Leader, USDA Agricultural Research Service [ARS]) gave a presentation to the CDS entitled 'Research towards Solutions to HLB: A Multi-pronged Approach ("it takes a village")'.

ARS funds a suite of projects (as part of its base funding, not competitive programs) addressing HLB from many angles, and spends more than $14 million on citrus research. Current epidemiological studies on surveying and detection include risk based surveys for early detection and monitoring, predictive models, simulation models to test mitigation methods, canine detection, and models that support agency needs for surveying. ARS is conducting work on thermotherapy, and has demonstrated symptom remission in both the greenhouse and in the field for up to 3 years after treatment. It was noted that this is the only therapeutic method ready for field use aside from suppression of the psyllid and removal of infected trees, however the long term impact of this therapy on the tree is unknown.

Many researchers are working on biocontrol methods – the psyllid has several predators because of the different life cycle stages, providing several opportunities for exploiting entomopathic fungi, predators such as ladybeetle and spiders, and parasitoids. ARS uses the Peco Farm facility in Fort Pierce, Florida, to test its citrus germplasm collection under high HLB and ACP pressure.

The long term goal is to identify citrus relatives that are sexually compatible with citrus but immune to HLB. The USDA began using *Poncirus* as a parent 110 years ago for its cold-hardiness but more recent studies show it and its hybrids have some HLB resistance. An ongoing survey in groves with multiple types of mainstream cultivars shows promise for identifying substantial resistance to HLB in conventional germplasm. Five new rootstocks showing tolerance to HLB were recently publically released, and four additional rootstocks are currently being evaluated. It was noted that tolerance and resistance in conventional citrus is desirable for living with HLB, but transgenics might be the most promising solution for conferring immunity to HLB. ARS is working to develop materials directly from citrus, but it was noted that regulation of any transgenic is an open question. ARS work on transgenic strategies encompass direct attack on the pathogen using antimicrobials, host-pathogen interactions looking at basal defense genes and *CLas* gene products, citrus physiology, and psyllid targets.

ARS is also working on antimicrobial therapies, including classical antibiotics for trunk applications (currently registered bactericides, new compounds in evaluation, RNAi and other work) and different methods for application and delivery, such as minimizing the surface area affected. RNAi-based strategies seek to interrupt a key process for insect survival by looking at very targeted genes specific to the psyllid. A promising RNAi-based strategy is currently moving through the patent process. It was noted that early detection methods continue evolving and it may be prudent to use multiple methods rather than rely on just one.

Dr Prakash Hebbar (National Coordinator, Citrus Health Response Program [CHRP], USDA Animal and Plant Health Inspection Service [APHIS]) updated CDS members on the work of both CHRP and MAC and the differences between the two entities.
Note: No presentation slides were used for this presentation.

The distinction between CHRP and MAC was made as follows: CHRP's work is more of a regulatory nature, including inspections of packing houses, citrus growers and nurseries, and development of diagnostic methods geared towards the regulatory program. MAC was initiated in December 2013 as a 2-year program in response to a need for better coordination among federal agencies and to ensure that federal research did not unnecessarily overlap with industry efforts. MAC will complement and fill research gaps, reduce duplication, and more quickly provide practical tools for growers.

MAC's $21 million appropriation must be obligated by September 30, 2015. There are two funding processes – direct funding and stakeholder suggestions. For the direct funding process, proposals were developed by the MAC group for the most promising tools identified by group members for large-scale field trials; projects in this category have been approved. Cooperative agreements totaling $5 million have been signed: $1.5 million for scaling up production and release of biocontrols, $2.5 million for antimicrobials and $1 million for demonstration of inoculum removal groves in Florida. The stakeholder suggestion process used an online system for industry and researchers to submit project suggestions. Approximately 50 were received in the categories of early detection, sustainability, and treatment of infected trees. The proposals were evaluated for timeline for impact, scalability, economic impact, end user involvement, adaptability across states, and for non-residential and non-commercial citrus. Approximately $8 million has been set aside so far for funding of these projects.

CHRP has approximately $13 million of funding, but is still operating under a continuing resolution that ends December 11.

PANEL DISCUSSION AND Q&A SESSION

Following the initial panel presentations, CDS members engaged in a question and answer session with the representatives from CRDF, CRB, CHRP and ARS. This discussion emphasized that research and development around citrus disease needs:

- Better coordination between all the different agencies and programs that provide funding for citrus disease research and development, including federal and state governments, non-profit organizations and private industry; and

- Better communication between those funding sources, current research projects, and the citrus growers / industry.

Particular issues of concern raised during the discussion were:

- *Antimicrobial resistance.* It was noted that the Food and Drug Administration, Centers for Disease Control and other agencies are very sensitive to the issue of antibiotic resistance with respect to human health. It was also noted that the USDA has developed an action plan around the issue of antimicrobial resistance in agriculture. However, the citrus industry is heavily dependent on bactericides to combat HLB, particularly in Florida. Hence antibiotics cannot be ruled out as an interim solution, but with the goal of finding a more sustainable solution moving forward.
- *Genetic modification.* Concerns were raised about how current consumer perceptions of genetically modified organisms (GMOs) would affect the citrus market if a new GMO or transgenic citrus plant were developed to be resistant to HLB and provide an effective solution. Similarly, concerns were raised about the impact on the organic citrus industry if a GMO product (either a citrus plant or biocontrol method, e.g. a GMO psyllid) were to be mandated. It was noted that each regulatory agency has an operational definition of 'genetically modified' and 'transgenic', but those definitions may differ between agencies.
- *Funding coordination.* It was noted that research on citrus disease is funded by many different entities, at a federal, state and private level, each operating with a different timeline and agenda. It is difficult for scientists to keep track of the various funding opportunities and requirements, and for growers to identify where new developments are coming from. Despite the efforts of MAC, better coordination and communication is needed.

This issue was further emphasized later in the meeting, as CRDF's research portfolio will be greatly reduced after 2015 and MAC funding must be obligated by September 2015, raising questions about which group(s) will fund necessary and ongoing foundational research.

A suggestion was made that CDS expand its work to assume the role of lead coordinator of information about citrus disease research. For example, CDS could organize an annual meeting / forum for researchers on citrus disease to share their work with each other and with growers. It was also suggested that CDS contact CDRE project directors and invite them to present research progress at future CDS meetings, in order to gain more up-to-date information both for reporting back to the citrus industry and for CDS to make more strategic recommendations to the USDA.

Several questions were posed to the panel members about the process for funding proposals and the most appropriate avenues for funding of different stages of a research project. Dr Tom Bewick (National Program Leader, NIFA) clarified that NIFA funds objectives rather than researchers or project titles. If a researcher is recommended for funding, that person is asked to declare any other sources of funding they have applied for or received; a researcher may only receive one source of funding for a given piece of work. However, it may be possible to receive multiple sources of funding for different stages of the same project: some near-term objectives might be funded through MAC and other long-term objectives might be funded through CDRE. Taking antimicrobials as an example, MAC would fund work to apply already-available products for HLB in the field, while CDRE would fund discovery work to design new products. Dr

MaryLou Polek added that researchers may have submitted proposals for the same work to multiple agencies because each entity's funding cycle is different.

In response to questions from CDS members, Polek clarified that the psyllid can be found throughout the Central Valley in California, though only one tree has so far tested positive for HLB. However, Polek noted that a single instance of infection is unlikely from a scientific perspective. Canine detection of the disease has not been tried but is being considered. Early detection and treatment biocontrol programs are currently focused in urban areas in California.

In response to a question, Paul Heller stated it has been 3 years since the first isolated grove of infected trees was found in Texas. Currently 3 production counties in south Texas are in quarantine. Heller clarified that quarantine in Texas means that plant material can't be moved to another part of the state, with the exception of fruit. A hot spot has been identified around the initial infection, but 'hot psyllids' (i.e. infected ACP) are being found on the periphery of that area, indicating the disease is spreading. Heller noted that the Texas industry is much smaller than California and Florida, encompassing about 30 square miles.

In response to questions from CDS members, Dr Gail Wisler clarified that ARS has not received any funding increases through the 2014 Farm Bill, but that this year was the first since 2010 that the ARS budget did not significantly decrease. Wisler noted that 10 research locations were closed 2-3 years ago and scientists were relocated, but currently the budget is stable. Michele Esch added that the new budget is in the review process now and USDA agencies recently received the pass back. Wisler added that HLB is recognized by the USDA as one of the most important problems in agriculture.

In response to questions from CDS members, Dr Harold Browning clarified that there are 3 proposals on thermal therapy that were rated highly enough to be accepted as projects. The MAC leadership group is working with the researchers to initiate contracts, aiming to start work on field evaluations in spring. These projects will work to scale up delivery of thermal therapy. Browning added that another MAC project is working on rootstocks. A formal press release about the funded projects will be made soon and details can't be released to the public beforehand.

In response to a question, Wisler noted that all rootstocks under consideration by ARS are from conventional breeding. Browning noted that a number of transgenic rootstock constructs are currently being tested by CRDF in Florida, but all commercially-available rootstocks are from conventional breeding. Wisler added that there is considerable hope that conventionally-bred rootstocks will exhibit tolerance to HLB while producing sweet fruit.

In response to a question regarding field testing of canine detection for HLB, Polek stated that two dogs have been obtained and 'imprinted' (i.e. trained to smell and focus on the compound(s) that indicate HLB presence). It takes approximately 6 weeks to complete this training. These two dogs have moved onto field testing. Polek noted that they want to conduct controlled trials in Florida to determine how quickly after inoculation dogs can detect the presence of disease. Once the researchers are confident that the two dogs are performing adequately, additional dogs will be trained. The proposal was for 30 dogs. This project is funded by MAC.

In response to a question about root sampling for HLB titre, Browning noted that some root sampling has been developed in Florida to better understand the behavior of the pathogen in the roots. However, extraction is more difficult and no one has done landscape-level root testing. One research group is working towards this. It is unclear what the relationship is between titre levels in the leaves compared to the roots of an infected plant, but there is most likely a dependence on seasonality and temperature.

In response to a question about organics research, Browning noted that CRDF is not funding any projects specifically for the organic market, but CRDF researchers are looking at essential oils that are registered for use in the organic market to see if / how they might address HLB. Hence organic methods are being considered as other tools in the toolbox of possible methods for tackling HLB. Browning also noted that thermal therapy is an organic method. Polek added that some organic work is being conducted in California, including the use of biocontrol agents. Bewick noted that the organic certification program is managed by the marketing side of USDA and is separate from those in the Research, Education and Extension (REE) division. Hence REE cannot guarantee that any strategies for combating HLB that might become mandated would be certified for organic growers. It might be possible for the MAC group to act as a conduit for conversations on that issue.

In response to a question, Bewick noted that all SCRI proposals must include an extension component. This component does not have to comprise a certain percentage of the budget, but must be a substantial effort that integrates into the project and not added as an afterthought. Sharing of information must occur throughout the project lifetime, not just afterwards.

PUBLIC COMMENTS

Two formal comments were received by the NAREEE Advisory Board office for entry into the public record.

Ms Sharon Garrett submitted the following comment:

> "Move faster or we are all toast."

Ms Laura Dawson, owner/member of Food Physics and Body Dynamics LLC, submitted the following comment:

> "As an alternative health care provider and a member of Codex Alimentarius Food Standards committee/s, I know the importance of this committee.
>
> We in the acupuncture and oriental medicine field in the US and worldwide use citrus peels therapeutically in a number of our formulas.
>
> For this reason, I am writing to request that in the efforts to save the citrus industry worldwide for the current diseased plaguing this fruit, you and other industry leaders refrain from placing any chemical topically on the peels that may put human health at risk.

If in fact you are unable to keep anti-fungal spray off of the fruit in order to preserve the crops, could you please include a safe 'bath' to remove the residue that may cause human maladies?

Thank you for taking the time to read and confirm receipt of this important email."

PART III: Citrus Disease Research and Extension (CDRE) Program

This session of the meeting was closed to members of the general public. Michele Esch read the following statement, to be entered into the public record:

"This meeting is being closed for the remainder of the day. The CDS is statutorily required by the 2014 Farm Bill to provide comments on the grants awarded in the previous fiscal year. The FY2014 CDRE grants have not been publicly announced by USDA and therefore cannot be shared with the general public due to intellectual property rights and the potential disclosure of proprietary information.

During the closed session, the subcommittee will hear information and discuss the FY2014 Citrus Disease Research and Extension Program grant awards. This information will help frame the priorities and agenda for the FY2015 CDRE. No formal recommendations will be made during the closed session."

Following the closed session, the meeting was adjourned for the day at 6:25 p.m.

WEDNESDAY, DECEMBER 10, 2014

Tom Jerkins (Chair, CDS) reconvened the meeting at 8:46 a.m. and introduced the day's agenda.

Part IV: Establishment of FY2015 Agenda and Priorities for the Citrus Disease Research and Extension

INTRODUCTION AND OVERVIEW OF DAY

Michele Esch reminded CDS members of the statute that governs the CDS.
Note: a copy of this statute can be obtained on request from the NAREEE Advisory Board office.

Esch noted that the CDS's charge is to provide guidance to the Secretary of Agriculture and USDA on citrus disease research and extension activities in general, not just on the CDRE priorities. Hence members should keep in mind any issues or areas of concern that they wish to include in a report and list of recommendations to the Secretary, in addition to the priorities for the FY2015 CDRE Request for Applications (RFA).

FORMALIZING RECOMMENDATIONS AND PRIORITIES FOR THE FY2015 CDRE PROGRAM

Discussion

Michele Esch opened the discussion by noting that the committee did a lot of work at the last meeting in May to establish an exhaustive list of industry needs, so it was probably unnecessary to repeat that exercise now.

CDS members were asked if the agenda for the FY2015 CDRE should once again focus solely on HLB. There was general agreement that HLB should continue to be the focus.

Tom Jerkins asked the committee if all of the available funding for FY2015 – $25 million – should be allocated for projects during FY2015.

There was general agreement that, for the foreseeable future, available funds should be obligated during each fiscal year.

It was noted that the closed session from the previous day had yielded a desire to focus the list of priorities on the next RFA, rather than have a wide-ranging set of priorities as in the last RFA.

A suggestion was made that each CDS member should indicate a single item as their top funding priority. This would provide a shortened list to consider. It was noted that the top priority in Florida would be bacteriacides, while the top priority in California might be early detection.

A concern was raised that narrowing the list of priorities too much would yield poor quality proposals if there wasn't enough depth in the researchers working on a given topic. It would be undesirable to fund projects that were of low standard simply because money was available, but it is unclear how many researchers / projects might exist that would meet the required standard for funding on the same topic. It was noted that all of the proposals rated 'outstanding' were funded in the last cycle. Hence if some of the same proposals were resubmitted, they might move up in the ratings and become eligible for funding. But it was also noted that on a given topic, such as antimicrobials, there might be many angles of research that are not already funded. So including the same priority on two consecutive RFAs might yield new ideas and approaches.

It was suggested that the wording on the RFA could be chosen carefully to encourage innovative ideas on an old topic. For example, saying 'bacteria elimination' instead of 'bacteriacide' might yield methods of killing the pathogen aside from chemical treatment or preventing transmission that have not yet been considered.

CDS members noted that they were limited in their ability to make recommendations about funding priorities given a lack of complete knowledge about the previous year's awards.

A question was raised as to the utility of culturing the *CLas* bacterium, in addition to research on killing / eliminating the bacterium. Dr Harold Browning noted that information such as the genome of the bacterium informs new approaches for culturing it. However, CRDF has spent

over $3 million since 2005/2006 on attempts to culture the bacterium and has not yet been successful. A culture can be kept alive for 50 days, but that is not sufficient time to build a bacteria screen. Browning suggested that the next step would be to include researchers in fields other than plant pathogens who deal with hard-to-culture microbes, such as oceanic microbiologists, who might use different tools that could be applied to *CLas*. Browning noted that not being able to culture the bacterium is a huge impediment to other research, including screening and treatment of the disease.

It was noted that a website was established for scientists working on culturing the *CLas* bacterium to share their work, in an effort to avoid duplicative failures. It was suggested that this website be updated and made available to researchers submitting proposals on this topic in the future to ensure that new, innovative ideas are proposed rather than repeats of failed methods. It was also suggested that a prize could be offered, similar to the X Prize competition, for the first team who can demonstrate a successful culture. This would be one way to attract researchers with applicable skills who are not working in citrus already. This prize could potentially be sponsored by the citrus industry or the new Foundation for Food and Agricultural Research created by the 2014 Farm Bill. NIFA is not able to offer incentives or prizes for research.

A question was raised as to the CDS members' ability to recommend budgetary amounts for individual priorities. Dr Tom Bewick noted that CDS is able to make any recommendations it sees fit, and all will be considered seriously, but that none are binding on NIFA. However, Bewick noted that NIFA generally does not allocate set funding for a given topic because the amount of high quality proposals may not fit the pre-allocated budget. The priority is to fund the best research, so the agency does not want to fund poor science in order to reach a set amount of funding awards. It was noted that the CDRE funds rollover, so any dollars not allocated in one year can be allocated in the next.

It was suggested that one way to ensure that cooperative research teams are formed to work on high priority topics is for industry members to recruit individual scientists to act as project leaders and coordinate proposals. However, because CDRE is a competitive grants program, any proposals submitted from such teams would still need to go through the formal review process and could not be guaranteed funding *a priori*. It was noted that the evaluation criteria for the relevancy component of the review process includes industry recruitment and support, so a research team assembled by industry members would be strongly considered.

Bewick noted that NIFA has a grant award for planning projects – $50,000 is awarded for a 12-month period for researchers to create a strategic plan for a grant award on a specific topic. Hence if CDS set a certain topic as a priority, for example culturing the bacterium, industry members could bring together a team of scientists to create such a plan and then submit a proposal in the next regular CDRE funding cycle.

It was suggested that another source of researchers and research funding is the private sector. If a wall has been hit in terms of accessing public scientists already working on citrus, a mechanism to access private industry researchers should be found. Bewick noted that industry researchers can apply for SCRI funding, possibly in collaboration with others. The requirement for making publicly-funded research publicly available might deter some private sector researchers.

However, it was noted that any project with potential intellectual property (IP) does not have to disclose the data until after it goes through patenting, providing protection for the private sector.

An argument was made that early detection of the disease might not be helpful if trees that are infected are not removed, or if the definition of 'infected' (i.e. titre above a prescribed level) means that a low level of inoculum allows a reservoir of disease to persist. A counter argument was made that early detection and removal of highly infected trees within a grove might allow the rest of the grove to remain productive for some period of time, delaying further income losses and buying time to treat the other trees. Hence early detection, particularly in California, might provide some degree of economic protection as long as it is accompanied by effective treatment and/or removal of infected trees. It was noted that methods of early detection need to be more accurate in order to prove infection before tree removal can be effectively mandated. Polek noted that early detection using the psyllid is difficult because not every psyllid will acquire the disease, so a large number of psyllids needs to be tested before disease can be ruled out. However, diagnosing infection in the psyllid is much simpler than in the host plant.

A suggestion was made that not all of the possibilities have been exhausted with regard to track and kill of the vector. However, there was general agreement that complete eradication of the vector is not a feasible goal, and that the vector is so efficient that even 99% removal would not be enough. Additionally, the current application rates of pesticides are not sustainable and to suggest increasing their use would not be wise. On the other hand, it was noted that existing traps often do not pull in psyllids even where they are known to exist, and in some places where they are suspected to live they cannot be found. Also, the vector population needs to be kept in check in order to achieve longer-term decreases in disease transmission. Therefore it might be worthwhile to do more work on attractants or attract and kill methods. It was noted that some attract and kill methods can also be used by organic growers. As a topic for research funding, it was suggested that the term 'vector suppression' is too broad and instead 'attract and kill' should be used.

Polek noted that CRB currently funds irrigation and nutrition projects looking at plant health, and a new project is looking at the plant's microbiota – what other organisms are present that help keep the plant healthy. Browning added that there is a lot of field trial research using compost and acids, attempting to identify the necessary inputs for tree growth, and that metabolic and genomic research will also aid in determining plant health in the presence of the bacteria. It was noted that resistant germplasm is an important topic for research and should not be excluded from the current priority list even if there are active projects on the topic.

It was noted that thermal therapy has shown to work but is not a bacteriacide, so perhaps another term needs to be used if thermal therapy is to be included on the priority list.

It was noted that the outcomes of projects that were funded through the last RFA will not be known for some time and may not be successful. Therefore topics that are of high priority should continue to be listed for the next RFA even if they were funded last time.

A suggestion was made to add juice quality as an issue in Florida. However it was argued that any problems with juice quality will be handled by the juice companies themselves. Although

private research will remain proprietary, and so it may be in the public interest to publicly fund researchers to work on juice quality, it was decided that the issue was not a high enough priority to include it in this RFA. Also, the juice-making brands may encounter consumer issues if juice quality is publicly raised as an important topic.

Concerns were raised that half of CRDF's portfolio will expire this year and it is unclear how that work, for example on conventional breeding for resistance, will continue. CRDF has been the primary funder of HLB research, so a question was raised as to whether the availability of funding should change the priorities for research. It was noted that both ARS and NIFA conduct foundational research and may be able to pick up some of the work that is lost when CRDF's funding expires. It was suggested that a chart listing all of the current efforts by CRDF, MAC and CDRE would be useful for all of the funding agencies to improve coordination of research efforts. Such a chart was created last year and should be updated annually.

It was suggested that the delivery system for any mechanism that kills bacteria needs to be considered, since it is the bacteriacide that penetrates the tree's phloem that is important. Hence the priority list should use language that includes the delivery mechanism. The phrase 'chemical and heat therapy systems to kill or suppress bacteria' would include both bacteriacides and thermal therapy, as well as the delivery mechanisms for bacteriacides.

Bewick stated that the RFA for CDRE will be similar to the other SCRI RFAs, but with the priorities developed from the recommendations set by CDS. From the time that NIFA receives the CDS recommendations, it will take 60 days before the RFA is released. It was decided that the list of priorities should be forwarded to NIFA as soon as possible following this meeting, so that the RFA can be developed, and then CDS will develop a more formal report based on the minutes of this meeting and describing the reasons for choosing those priorities in more detail.

It was noted that CDS and the industry won't have access to the scheduled reports from grants that are awarded now by the time the next recommendations need to be made. Perhaps some other mechanism can be created by which CDS can get more frequent updates from researchers. MAC requires quarterly progress reports. NIFA only requires annual project director meetings, but SCRI requires that all project teams maintain a website. Most projects have at least biannual meetings with their advisory committees and reports from those meetings are made available on the project websites. CDS and other interested parties can be directed to those websites. NIFA can also ensure that CDS has access to information about new grant awards, including abstract, project personnel, budget and contact details. However, if industry requires more frequent updates from funded projects, CDS members could call the project directors directly, invite project directors to present at CDS meetings, or organize a research forum to bring scientists together to share information.

Bewick stated that in writing the RFA, the document could state that the funding priorities are based on consultation with CDS and are listed in ranked order. That would ensure that the rankings of priorities as determined by CDS were communicated through the RFA.

Identification of FY2015 Priorities

A list was created of the priorities for each of Florida, Texas and California, as follows:

- Florida: bacteriacide, fruit drop.
- Texas: bacteriacide, early detection, fruit drop, attract and kill / suppression, resistant germplasm.
- California: early detection in host and vector, bacteriacide, attract and kill / suppression, resistant germplasm.

Culturing (cultivating) of the *CLas* bacterium was also listed as a general priority, since the current inability to produce a lasting culture inhibits further work on screening and killing bacteria in the host plant.

These topics were compiled into a single list, as follows:

- Chemical and heat therapy systems to kill or suppress bacteria
- Early detection of bacterium in host tree or psyllid
- Cultivating bacteria
- Fruit drop
- Attract and kill / suppression
- Resistant germplasm

Each CDS member then ranked these topics in order of priority. The results were combined to give the following rankings:

1) Chemical and heat therapy systems to kill or suppress bacteria
2) Cultivating bacteria
3) *Tie*: early detection of bacterium in host tree or psyllid; resistant germplasm
5) Attract and kill / suppression
6) Fruit drop

A motion was put forward to move early detection up to the second priority and to cut the list to four priorities, excluding fruit drop and attract and kill / suppression. The motion was seconded.

Ensuing discussion led to an amended motion: leave cultivating bacteria in second place, set early detection in third place and resistant germplasm in fourth place, and exclude the last two items. The amended motion was seconded.

There was further discussion about whether to cut the list to 4 items or leave it with 6 items in order to include attract and kill / suppression. Concerns were raised that having a shorter list might lead to proposals of lower quality being funded or an innovative idea on a different topic being excluded. However, equally of concern is that having a longer list would dilute the effort on topics of highest priority.

Bewick acknowledged that the RFA can't be exclusive to the priority list created by CDS, and this list does not preclude proposals being funded on other HLB-related topics if they are of sufficiently high quality. But all proposals will be reviewed for relevancy against this list of priorities, so a shorter list will narrow the focus.

SUMMARIZE AND FORMALIZE FINAL PRIORITIES AND RESEARCH AGENDA

Tom Jerkins called for a vote on the amended motion: only 4 priorities to be included in the FY2015 RFA in the following ranked order:

1. Chemical and heat therapy systems to kill or suppress bacteria
2. Cultivating bacteria
3. Early detection of bacterium in host tree or psyllid
4. Resistant germplasm

The motion was passed with 7 verbal votes in favor and 1 opposed.

A motion was put forward that the agenda for the FY2015 RFA be focused on HLB. The motion was passed with a unanimous verbal vote.

A motion was put forward that the budget for the FY2015 RFA allow spending of the $25 million allocated for FY2015. Several questions were raised about the flexibility in budget spending. In response, Bewick noted the following:

- NIFA uses continuation awards as a way to get as many projects started as possible within the constraints of the available budget. The agency's practice is not to extend past the authorized life of the program, which is 5 years in the case of CDRE. So for projects that NIFA has indicated will have obligated funds in the future, it will not extend those funds past the 5-year mark.
- From the first year's awards, some funds have been obligated for years 3 and 4 of the CDRE lifetime, but none for years 2 or 5.
- NIFA cannot authorize more than $25 million in any given year. However, if some funds were not obligated in one year, they can be rolled over into the next. NIFA's goal is to use all of the available funds for projects, so the small amount that was leftover from FY2014 will be used to fund projects in FY2015.

Jerkins called for a vote on the motion to set the budget for FY2015 at $25 million. The motion was passed with a unanimous verbal vote.

WORKING SESSION

General Recommendations to USDA

CDS members engaged in a substantial discussion about more general aspects of citrus disease research, extension and education as per the committee's charge. The following items were noted as topics for further discussion and making recommendations to the USDA:

- Citrus disease researchers are currently excluded from scientific merit review panels because of concerns about conflict of interest. Questions were raised that this exclusion limits the ability of reviewers to adequately judge proposals for scientific merit. Bewick noted that it is a significant challenge to find reviewers with sufficient expertise in bacteria, vector diseases, horticultural systems, breeding of woody plants and related fields, and NIFA relies heavily on the scientific community to recommend appropriate reviewers. Another challenge is that

participation on a review panel is a heavy time commitment (3 weeks). NIFA tries to retain about 30% of reviewers from one year to the next to provide institutional memory, but identifying the new 70% of reviewers each year is difficult. If CDS would like to suggest changing the conflict of interest policy to include citrus disease researchers on the review panels, CDS can make such a recommendation to the Under Secretary.

- Considerable frustration was expressed by CDS members that they were not presented with sufficient detail about the recent grant awards to make the necessary recommendations for the second year of funding. A recommendation was made that if a CDS meeting includes a closed session, CDS members should be entrusted with privileged information for the purposes of making necessary recommendations to the USDA.

- Considerable expertise and funding lies within the private sector and some mechanism for accessing that information publicly should be found. It was noted that the new Foundation for Food and Agriculture may provide a way to supply funds for a large award that could be matched by industry dollars and bring private researchers into a collaborative team.

- In order to make sure that CDS input on funding decisions is clear, RFAs should adhere to the priorities set by CDS and press releases about the awards should include a statement to indicate stakeholder approval of those priorities.

In addition, CDS members returned to a discussion of the significant coordination and communication issues described previously (see pages 8-9). It was noted that there are two parts to the current perceived lack of communication / coordination: getting progress updates out to the industry and growers in a regular and timely fashion, and ensuring that all entities funding research (including MAC, APHIS, NIFA through SCRI and CDRE, CRB, CRDF, CHRF, and the private sector) are sharing information to prevent unnecessary duplication of efforts. It is unclear whose responsibility it is to lead this coordination effort, given the existence of HLB-MAC, but that role does fall within CDS's charge. The Office of the Chief Scientist within USDA could also play a role.

If desired, CDS could make recommendations to the Under Secretary about various methods for sharing information, such as regular research forums or better communication of website material to growers. One possibility is to create an email listserv for the citrus industry, like the one that exists for SCRI, in which all subscribed email addresses are sent a link to a specific website when new material is posted.

CDS could also take the initiative to expand its current tasks and take on a leadership role for coordination. It was noted that in order to assume such a leadership role, CDS would need to meet more than the current once per year. Esch will investigate whether the budget allows for two in-person meetings per year. Conference calls may also be a method for regular contact between members. Regular contact will also allow for more frequent updates from funding agencies, which can then be communicated back to the industry represented by CDS members. It is also within CDS's purview to invite researchers to present research updates at meetings.

It was suggested that CDS recommend to the Under Secretary that a detailed project description be released to CDS members for each project funded through CDRE, so that CDS can provide more details back to the industry.

Scheduling of Next Meeting

It was suggested that the next CDS meeting be scheduled for somewhere in California.

A conference call will be scheduled after the USDA issues a press release about the FY2014 awards, in order to get feedback from CDS members. This call should be scheduled fairly quickly but with enough time for CDS members to read the details of the awards. Michele Esch will send out an online ('doodle') poll to find an appropriate time.

A request was made that the next CDS meeting to provide recommendations on CDRE funding be held only after the awards for the previous funding cycle are released, so that CDS members can have as much information about current awards as possible. Bewick stated that he would have a good estimate of the timing for awarding grants once the RFA is published. If CDS schedules its meeting for one week after the awards are made, USDA can time the press release about the awards to coincide with the meeting.

Report for USDA

CDS will need to develop a report, including formal recommendations, about the discussions and outcomes of this meeting for forwarding to the Under Secretary of Agriculture, the Secretary and the relevant appropriations committees. After the report is written, it will be forwarded to the Executive Committee of the NAREEE Advisory Board for review before being finalized.

It was suggested that a small working group be formed to write this report. Tom Jerkins and Dr Etienne Rabe volunteered to write the report.

It was suggested that the report be concise and specific in detail and recommendations. But it should include some background as to how certain conclusions were reached and provide rationale for any decisions that were made.

Since NIFA requires 60 days to finalize the RFA, it is in CDS's best interest to forward the priorities for the FY2015 RFA to NIFA as soon as possible. So CDS will create two documents: a short report containing only the priority recommendations, and a longer, more formal report with details of the rationale behind the priorities and all other recommendations as describe above.

Other Business

Michele Esch described the procedure for obtaining reimbursements for travel expenses.

PUBLIC COMMENTS

There being no public comment, the formal meeting was adjourned at 2:20 p.m.

THURSDAY, DECEMBER 11, 2014

Tour of the Citrus Research and Education Center, University of Florida

A tour was organized of current research activities, laboratories and demonstrations at the Citrus Research and Education Center at the University of Florida. This tour was optional for CDS members.

Participants assembled at the Ben Hill Griffin Hall at the University of Florida campus at 8 a.m.

Dr Reza Ehsani – Thermal Therapy

The first demonstration was given by Dr Reza Ehsani on a new technique for thermal therapy. His recently developed heat machine uses dry heat to provide steam around a single tree at a temperature of about 58 ^{o}C (136 ^{o}F). At this temperature, the tree only needs to be exposed for 30 seconds. Ehsani stated that it only takes 2 minutes to complete treatment of one tree, including the time for moving the machine between trees and lowering / raising the curtain.

Based on the results so far, the heat treatment seems to only kill bacteria in the shoots, not the roots. The effects of treatment last about 2 years before the infection returns. About 1600 trees have been treated with this machine in the last year. By adjusting the temperature and time of exposure, they have been able to achieve zero fruit drop and minimal leaf loss. The cost is approximately $5-6 per tree, which is considered a worthwhile expense if no fruit drop occurs.

Ehsani's group is beginning work to provide heat treatment to root systems using ground penetration. They are still working on the design and dealing with the engineering mechanics of optimizing the pressure, temperature and wetness of the steam, the spacing of injections, and so on. Ehsani noted that treatment of roots could have other benefits in killing nematodes and other predators / parasites of the tree, but there could also be negative effects, especially if heat treatment is being combined with other belowground treatments.

The heat machine can treat about 70 trees per day in 8 hours of work (which includes the time needed for driving the machine around), and uses 100 gallons of water for those 70 trees. It was noted that this is a much more time efficient method of treatment compared to solarization, which requires 3 days for heat to build up inside the curtain to a sufficient level for treatment.

Ehsani noted that their current machine is most suitable for smaller, younger trees with less infection – the smaller trunks and required curtain allows for better, more uniform control of the internal temperature. They have not yet tested combining the steam treatment with antibiotics but there could be added benefits of doing so.

Dr Jude Grosser and Dr Fred Gmitter – Plant Improvement Program

Between the researchers' two groups, they cover all they can do with respect to genetic improvement of citrus, including genomics, gene sequencing and bioinformatics. They are focused on solutions for industry and the production of new varieties. For example, they can recreate or restructure sweet orange by making crosses using an appropriate selection of parents and introducing "HLB-antagonistic" genes.

As a proof of concept, Grosser and Gmitter presented fruit to taste from a sweet orange tree that contains approximately 8% of genes from a plant that has shown great resistance to HLB. This is the first tree they have grown of this type that produces juice acceptable for commercial use. This tree is considered non-GMO since it was bred conventionally (but selectively) and only contains citrus-to-citrus gene transfer.

They are also finding trees in the field that are exhibiting high resistance to HLB with only minimal signs of disease and maintaining productivity. They are finding genetic tolerance in existing germplasm so are conducting genetic screening to isolate those plants. They are also experimenting with tree nutrition.

Dr Lukasz Stelinski – Biology and Management of Asian Citrus Psyllid

Stelinski's group in entomology and chemical ecology works on the biology of ACP. Since insecticides are the main tools in fighting HLB, they want to maintain their effectiveness as long as possible, so the group works on resistance in the psyllid, attractants, and the biology of the psyllid to better understand methods of control.

They conduct an annual survey of trees to look at the insecticide response of the psyllid. They are finding a dynamic enzymatic response and a changing level of resistance – a few years ago they noticed high resistance, but in the last couple of years there has been lower resistance. They have also seen what are likely to be permanent changes in the psyllid populations. They are working on a method to do real-time field testing of psyllid resistance. There is not currently an issue with resistance but one could develop given the dynamics of resistance and known propensities for KDR mutations (which lead to resistance) in a wide range of insects.

With regard to biology of the psyllid, Stelinski's group is studying the flight of individual psyllids. They have found that an individual psyllid can travel a total distance of up to 2 km without wind assistance; this result has been confirmed in the field. In the laboratory, they have seen psyllids fly continuously for up to 3 hours at a time, covering a distance of 500 m in one flight. Infected psyllids are shown to initiate movement more and travel longer distances than uninfected psyllids. This is the first time that a bacterial pathogen has been shown to affect the movement of an infected insect. Infection doesn't change the total movement over a psyllid's lifetime – there is probably some energetic reservoir boundary that prohibits more than some predetermined total amount of movement – but infection does increase the flight length per flight.

Current work is testing which type of plant / attractant is more attractive to psyllids. They have consistently shown that uninfected psyllids are more attracted to infected plants than uninfected plants. They have identified volatile organic compounds (VOCs) from infected plants that can be used as attractants, which have proven more attractive than a natural citrus plant. Although uninfected psyllids are more attracted to infected plants, they can't feed as long on the infected tree (compared to an uninfected tree), so they initiate movement quicker after feeding. Since the psyllid will now become infected after feeding, this behavior helps to spread the disease. The researchers have found that the most attractive blend of VOCs are not variety specific or specific to a time of year in terms of its effectiveness in out-competing natural citrus.

Psyllid movement is also cued by light. This is why more psyllids tend to be found at the edges of groves, where there is more light, than in the interior. The researchers have found a 50-75% reduction in psyllid numbers along the borders of 5 groves when a wind break was used, as the wind break casts a shadow on the border trees. Similar repellant effects are found by using reflective materials on the ground – these confuse the psyllid as to which direction the sun is coming from, and disrupt its movement.

Dr Arnold Schumann – Advanced Citrus Production Systems / CUPS

Schumann's group is looking at alternative fruit production systems, and Advanced Citrus Production Systems (ACPS). They have had some success with an ACPS – showed that the grove is HLB-free for 4 years running with good yield and a high density of trees (363 trees per acre, producing 622 boxes of fruit per acre). But in the fifth year, HLB caught up and led to more than 75% infection. Part of the problem is a bottleneck as the tree gets bigger: as there is more foliage, it is harder to keep protecting the tree with pesticides.

Schumann noted that the problem is total psyllid control. They need complete psyllid exclusion to prevent HLB from spreading. They can keep the trees alive and producing fruit even in the presence of infection but the fruit quality isn't acceptable.

They are looking for alternative techniques, such as screen houses to keep insects out. They found a grove in California where trees were grown in containers inside a screen at very high density (nearly 2000 trees per acre, producing 1600 boxes of fruit per acre). Those trees were still healthy at year 5.

CUPS is the Citrus Undercover Production System being trialled in Schumann's group. Schumann noted that plant growth under a screen house is about twice as fast as outside the screen house because of the controlled light. Other techniques can also be administered within the screen houses, such as using ground covers to reflect light back and improve canopy lighting. Another benefit of the screen house is that it provides a wind break, and also eliminates sun burn. The screen houses can withstand tropical storms and therefore are suitable for central Florida since hurricanes are generally downgraded by the time they reach the center of the state.

Their current screen house trial has been running for 8 months. They are currently trialling different planting densities. Most plants in the screen house are in pots, but there is a small section where test plants are in the ground.

One of the benefits of screen houses is that they allow for use of organic sprays and fertilizers, and hence can provide for HLB-free organic production. Schumann noted that all of the work with CUPS and thermal therapy is non-regulated and non-chemical, which is perfect for organic growers.

Schumann noted that the benefit of a container is that you can do thermal therapy on the root ball easily, and his group has successfully killed bacteria from the roots this way. The container is placed into a steam house for 48 hours at about 42 ^{o}C.

Another method Schumann's group is trialling is growing the plants in pots in an open field. The pots allow for thermal therapy to eliminate bacteria in the roots, but because the field is open a pesticide spray is given every 1-2 weeks. They have grown HLB-free citrus this way. They are testing different pot designs to prevent root circling.

Schumann noted that the screen house methods are probably best suited to gift fruit and smaller growers due to the cost. A screen house has a life span of 5-7 years before it needs to be replaced. The cost is approximately $30,000-40,000 per acre, although the cost per acre decreases with increasing area. Schumann believes that his group can achieve sufficiently high yield and fruit quality within the screen house that it can pay for itself.

Dr Bill Dawson – RNAi / "Psyllid Shield"

Dawson noted that after 30 days, a previously healthy tree that was exposed to 25 infected adult psyllids will present as PCR positive for infection, and the psyllids that were born on the tree will be 30-80% PCR positive. So if growers want to detect infection early, they have 15 days – the time taken for a healthy tree to have psyllid eggs and nymphs after exposure to infected adults. In tests within Dawson's group, they have seen trees exhibit disease symptoms as early as a few months after infection, but they have sampled trees that are PCR positive only 10 days after exposure.

Dawson talked about his group's work using CTV (Citrus tristeza virus). They haven't found many things that work against HLB yet. However, they are finding huge decreases in the number of psyllids and a reduction in uptake of HLB in the surviving psyllids – a lower percentage that are PCR positive. The bad news is that they don't have time to learn anything from the field tests because what they are doing is looking at the spread of disease and psyllids, and the industry in Florida does not have time to look at spread in the field. Therefore Dawson's group is doing modelling studies to try to predict more quickly the impact on spread in the field.

Varietal Display Meeting

A display of new varietals was hosted by the Citrus Research and Education Center at the University of Florida. This display was optional for CDS members and open to the public. The display was held at the Ben Hill Griffin Hall and began at approximately 10:15 a.m.

RESOLUTIONS, RECOMMENDATIONS AND ACTION ITEMS

Resolutions and Recommendations

- CDS developed and approved an agenda, budget and list of four priorities to be provided to NIFA for the development of the CDRE RFA for FY2015.
- Future CDS meetings to discuss recommendations for the CDRE program should not be held without members having prior access to the details of new funding awards.
- CDS should meet twice per year in person and possibly more frequently via conference call.

Action Items

- CDS will develop a report and recommendations based on the minutes of this meeting. This report will be reviewed by the NAREEE Advisory Board and, once approved, forwarded to the Secretary of Agriculture.
- NIFA will provide CDS with information about newly funded projects as soon as possible, including project director, other project personnel, abstract, budget, and contact details.
- Executive Director will schedule a conference call once the CDRE awards are announced.
- The next meeting of CDS will be scheduled for a week after the intended date for awarding the next cycle of grants, to be determined once the RFA is published.

APPENDIX A: LIST OF MEETING ATTENDEES

A list of public attendees is available from the NAREEE Advisory Board Office.

Tuesday, December 9

PART I: WELCOME AND INTRODUCTIONS

CDS Members Present: Justin D. Brown, Joe Davis, Jr., Paul Heller, David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr Etienne Rabe, Dr Mark McLellan (NAREEE Advisory Board Representative).
CDS Members Absent: Donald Roark.
NAREEE Advisory Board Staff: Michele Esch.
Other USDA Staff: Dr Tom Bewick, Dr Gail Wisler.
Invited Guests: Dr Harold Browning, Dr MaryLou Polek.

PART II: CITRUS DISEASE RESEARCH EFFORTS AND ACTIVITIES

CDS Members Present: Justin D. Brown, Joe Davis, Jr., Paul Heller, David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr Etienne Rabe, Dr Mark McLellan (NAREEE Advisory Board Representative).
CDS Members Absent: Donald Roark.
NAREEE Advisory Board Staff: Michele Esch.
Other USDA Staff: Dr Tom Bewick, Dr Prakash Hebbar, Dr Gail Wisler.
Invited Guests: Dr Harold Browning, Dr MaryLou Polek.

PART III: CITRUS DISEASE RESEARCH AND EXTENSION (CDRE) PROGRAM

CDS Members Present: Justin D. Brown, Joe Davis, Jr., Paul Heller, David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr Etienne Rabe, Dr Mark McLellan (NAREEE Advisory Board Representative).
CDS Members Absent: Donald Roark.
NAREEE Advisory Board Staff: Michele Esch.
Other USDA Staff: Dr Tom Bewick.

Wednesday, December 10

PART IV: ESTABLISHMENT OF FY2015 AGENDA AND PRIORITIES FOR CDRE

CDS Members Present: Justin D. Brown, Joe Davis, Jr., Paul Heller, David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Dr Etienne Rabe, Dr Mark McLellan (NAREEE Advisory Board Representative).
CDS Members Absent: Donald Roark.
NAREEE Advisory Board Staff: Michele Esch.
Other USDA Staff: Dr Tom Bewick, Dr Prakash Hebbar.
Invited Guests: Dr MaryLou Polek.

Thursday, December 11

TOUR OF THE CITRUS RESEARCH AND EDUCATION CENTER

CDS Members Present: Paul Heller, Dr Etienne Rabe.
CDS Members Absent: Justin D. Brown, Joe Davis, Jr., David F. Howard, Tom Jerkins, Ricke A. Kress, Matthew McLean, Donald Roark, Dr Mark McLellan (NAREEE Advisory Board Representative).
NAREEE Advisory Board Staff: Michele Esch.
Invited Guest: Dr MaryLou Polek.

APPENDIX B: PRESENTATONS

Presentations made to CDS members, available upon request to the NAREEE Advisory Board Office:

- 'HLB Research and Delivery of Solutions, Florida Industry Research Overview', from Dr Harold Browning (Chief Operations Officer, Citrus Research and Development Foundation, Inc. [CRDF])
- 'Citrus Research Board', from Dr MaryLou Polek (Vice President, Science and Technology, California Citrus Research Board [CRB])
- 'Research Toward Solutions to HLB: A Multi-pronged Approach ("it takes a village")', from Dr Gail Wisler (National Program Leader, USDA Agricultural Research Service [ARS])