PROCEEDINGS: 2016 COFFEE BERRY BORER SUMMIT AND CONFERENCE

EDITORS:
Andrea M. Kawabata, Stuart T. Nakamoto, R.T. Curtiss, and Raymond Carruthers

Proceedings:
2016 Coffee Berry Borer (CBB) Summit and Conference

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On March 15, 2016, twenty-nine researchers, educators, government representatives, project investigators, and support personnel involved with coffee berry borer (CBB) research, education, and outreach in Hawai'i and Puerto Rico gathered at the Komohana Research and Extension Center in Hilo to participate in the 2016 CBB Summit. This meeting was co-hosted by UH CTAHR Extension specialist Dr. Raymond Carruthers, UH-CTAHR coffee and orchard crop Extension agent Andrea Kawabata, UH-CTAHR Extension economist Dr. Stuart T. Nakamoto, and HDOA entomologist Rob Curtiss.

The goal of the 2016 CBB Summit was for participants to learn about ongoing CBB research projects and Extension efforts and to provide networking opportunities. Seventeen speakers conducted brief PowerPoint presentations followed by question-and-answer sessions.

The following day (March 16), a CBB Conference was held in Kailua-Kona at the Courtyard King Kamehameha's Kona Beach Hotel. Eighteen speakers provided updates to 171 participants about the overall CBB Areawide Program and the research and outreach related to CBB mitigation and control taking place in Hawai'i and Puerto Rico. A panel discussion followed each group of speakers, and the audience was provided an opportunity to ask questions about each presented subject area.

The abstracts and other materials provided by the CBB Summit and CBB Conference speakers are compiled into the following 2016 CBB Summit and Conference Proceedings.

Acknowledgements

Event co-hosts would like to thank funding agencies USDA, HDOA, and UH CTAHR for providing funding for this event, which supports the Extension, research, and outreach activities that are so vital to Hawai'i and Puerto Rico's coffee industries. They would also like to thank USDA-ARS DKI PBARC and UH CTAHR staff and administration for providing the facilities, equipment, and support staff to host this meeting and conference. In addition, they send their appreciation to all event participants and presenters, as their work is invaluable to the coffee industries, and also to the Office of Research Services for their assistance in the review and publication of these proceedings.

Table of Contents

Abstract: Areawide Pest Management Program – USDA Agricultural Research Service

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In 1994, the USDA recombined previous funding to develop the Integrated Pest Management Initiative, which had an initial broad goal of achieving integrated pest management on 75% of the US crop acreage by the year 2000. One major effort in this initiative was the Areawide Pest Management Program under the Agricultural Research Service (ARS). But in reality, the concept of an Areawide Pest Management strategy is older than this program. The concept was developed by Dr. Ed F. Knippling over the course of his career, which started in the 1930s. Knippling's idea was to improve pest control using pest-specific approaches in a way that reduced pesticide use and protected the environment. He is most well known for eradicating screwworms, a cattle parasite, from the US and Mexico using sterile-male releases. Sterile males do not attack cattle, but their inundative release tricked the females into mating with unfruitful partners, since the sterilized males were so abundant. This strategy effectively prevented the majority of females from laying fertilized eggs, thus killing off this species in the United States. As you can imagine, this type of strategy must be carried out over the entire affected area, or at least along the invasion front, to be effective. And thus, the areawide concept was born.

The purpose of the current ARS Areawide Pest Control Program is to develop effective, sustainable strategies for controlling pests of significant economic or ecological consequence, but also to target pests that require an areawide approach for effective control. Many pests can be controlled by individual farmers or landowners, if they effectively treat their own property. But some pests cannot be controlled in this way. Many insect pests can fly long distances, or migrate during certain stages. Some weeds have seeds or other reproductive stages that move rapidly in the air or water, allowing them to repeatedly re-invade previously treated areas.

The intention of an Areawide is to help local people develop an effective solution to their own problem. ARS provides critical funding to organize and implement the needed expertise and control strategies, and the funding also provides monitoring and scientific oversight to evaluate pest control efficacy. The development of an Areawide is not the time for fundamental, exploratory research. It is the time to scale up previously developed pest-control tools and coordinate a variety of efforts into an effective control strategy. A successful Areawide develops a pest-control program that will continue beyond the ARS funding. Examples of previous ARS Areawides include codling moth control in NW apples; fruit flies in Hawai'i; the silverleaf whitefly in the southern US; control of Melaleuca, a highly invasive tree that was taking over the Florida Everglades; and the coffee berry borer in Hawai'i. As we will learn today, a critically important component of an Areawide is coordination and communication with those who hold stake in the successful control of the pest.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Areawide IPM Overview for CBB Mitigation

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The coffee berry borer is one of the most devastating pests of coffee worldwide. It was recently discovered throughout the Kona coffee-growing region in Hawai'i and more recently on the island of O'ahu. In response to the invasion and thanks to strong industry support, Hawai'i congressional delegation support, and the support of many others, an areawide mitigation and management program for CBB control was established by PBARC in August 2013 with funds received from ARS ($1M) in collaboration with the University of Hawai'i at Mānoa under an initial Specific Cooperative Agreement (SCA). The overall goal was to help growers deal with the CBB problem in an environmentally sound and economically viable way. Some of the original objectives included optimizing the dose and use of commercial *Beauveria*, mapping the area and extent of the infestation, understanding the insect phenology, synchronizing coffee blooms for harvest and sanitation, providing area-wide education and Extension outreach, and developing an economic analysis of CBB effects and cost/benefit of control measures. This allocation included four scientists from USDA-ARS, PBARC and five from CTAHR. In September 2014, another $703,358 ($683,334 to project) was secured under Amendment no. 1 to the initial SCA. Scientists added to the project included three from PBARC and one from CTAHR. Additional objectives included reducing field populations of CBB using semiochemicals, entomopathogenic nematodes (EPNs), predators, and pruning styles; improving quarantine treatments; and implementing preventative and/or management measures to additional islands. In 2015 another $1M (~$700K to Hawai'i & $300K to Puerto Rico) was secured under Amendment no. 2 to the initial SCA.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Overview of the Puerto Rico CBB Areawide IPM Effort

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The coffee berry borer (CBB) (*Hypothenemus hampei*) was first detected in Puerto Rico in 2007. We initially developed an extensive survey of CBB in the main coffee-growing area in Puerto Rico, sampling 214 sites in 97 farms and rural areas in 17 municipalities from August to November 2014. Plants sampled were predominantly *Coffea arabica*. The survey sites were chosen to include a range of farm sizes, agronomic management, and coffee agroecosystems (i.e., coffee plants growing in direct sunlight and growing under the shade of a mix of canopy trees, coffee intercalated with citrus trees and bananas, abandoned coffee farms, and naturalized plants). Sites ranged from 35 to 982 meters altitude and included the lowest and highest coffee farms in Puerto Rico. We conducted surveys for alternative plant hosts in vicinities of coffee farms. The CBB is causing severe damage to Puerto Rico's coffee crop, especially at intermediate to high elevations. The pest infestation in Puerto Rico in 2014 was more severe than previously reported in other coffee-growing countries, up to 85% depending on site and altitude. We tested species-distribution models to allow projection of the potential distribution of target species, based on the relationship between species' bioclimatic variables and their ecological requirements. Nineteen bioclimatic variables along with altitude were used. In addition, several activities have been established: a large number of isolates of *Beauveria bassiana* were obtained, and screening for their efficiency to control CBB is underway; entomo-nematodes were isolated from coffee fields; coffee experimental blocks were established; and lectures and meetings with stakeholders and professionals involved in coffee production were conducted.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: UH CTAHR 2015-2016 CBB Educational Outreach Efforts

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In just over 2.5 years of funding under the Specific Cooperative Agreement "Area-wide Mitigation and Management for Coffee Berry Borer (CBB)" (#58-5320-3-017) between the USDA ARS DKI PBARC and UH CTAHR, Extension has made an impact on the way that farmers control CBB. These efforts are in collaboration with coffee farmers and producers, USDA, UH CTAHR, Hawai'i Department of Agriculture (HDOA) scientists and staff, the Synergistic Hawaii Agriculture Council (SHAC) program, and other UH Extension faculty and staff.

Since the arrival of CBB, producers have been required to change the way that they farm and process coffee. Outreach has been important for the dissemination of information about CBB-mitigating cultural practices and technologies. Adoption of these new techniques and technologies is key for the control of CBB populations and mitigation of crop damage.

Since 2013, surveys suggest that there has been increased adoption of field sanitation and the use of strip-picking after harvest to remove residual breeding sites for CBB, one of the most critical components of CBB integrated pest management. The adoption of the 30 or 12 Trees sampling and monitoring method and the frequency of its use have increased. *B. bassiana* application frequency has also increased, although some growers have reduced their application rate. In part, this has led to the stabilization of the coffee industry (marketable green bean recovery rate in 2013 was 6.3 and in 2014 was 6.2) and slight decrease (2014 – 19%; 2015 – 17%) of unmarketable coffee due to CBB.
Besides the adoption of cultural practices to manage CBB populations and damage to green coffee, other challenges for the outreach program include keeping CBB IPM information new, exciting, attractive, and relevant, and relaying the importance of coffee quality related to CBB IPM and the future of Hawai'i's coffee industry.

In an effort to overcome these challenges, workshops, field days, and educational booth displays have been focused on new CBB IPM updates, coffee quality for farmers, and increased interactions with and hands-on participation by event attendees. Additionally, knowledge of CBB control and farm and mill efficiency for mechanized farms was the focus during the statewide coffee conference and during a visit by mechanical engineer Mr. Fernando Vicentini of Brazil, in late October to November.

Outreach and grower education is ongoing. Since the last (May 2015) CBB Summit, 457 participants have been educated about CBB and CBB-related topics. Updates are frequently provided to growers via emails, mail-outs, Extension publications, posters, presentations, educational booths, Facebook (Kona Orchard Crops), and hawaiicoffee.weebly.com.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Synergistic Hawaii Agriculture Council

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SHAC is entering the fourth year of its USDA Technical Assistance for Specialty Crops grant, which subsidizes *Beauveria* costs for growers. In 2013, the grant began by focusing on the South Kona 8-4 tax map region, as well as the Kāʻū district. In 2014 it was expanded to include all CBB-impacted farms in Hawaiʻi. The last potential year for funding in this grant is 2017.

To enroll in the grant, growers are required to attend a 1- to 2-hour training session on IPM, perform sanitation on their trees, and monitor their farms using a variation of the 30 Trees method. Participants are then eligible to receive a subsidy on the *Beauveria* products Botanigard® or Mycotrol®. In 2015, this subsidy was 75% off the retail price.

To date, over 25 classroom training sessions have been offered and numerous farm visits made. Over 850 farmers have attended the trainings. SHAC has 640 tax map keys (TMKs) registered in the grant program, representing over 4,800 acres. According to a cross-reference of regional wet-mill data, the combination of an educational component with subsidy of the *Beauveria* products has driven an overall drop in crop damage.

Growers may join the SHAC program by emailing info@deadcbb.com or calling 808-365-9041.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Understanding the Biology and Life Cycle of CBB for Better Management Practices

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The coffee berry borer is a tiny beetle (1.2–1.8 mm in size as an adult) that belongs to the bark beetle sub-family. It is the most damaging pest of coffee worldwide. Female beetles bore into developing coffee berries, construct galleries inside developing coffee beans, and deposit eggs there. The life cycle of newly formed larvae, up to their emergence as adults, is completed entirely inside the coffee berry. This peculiar biology and covert life cycle of this pest inside the berry make this species one of the most difficult pests to manage in coffee. Understanding the biology and life cycle of this pest is important to facilitate design and implementation and to ensure adoption of management strategies. Here we discuss the biology and life cycle of this pest and factors affecting its management with emphasis on behavior, reproduction, emergence, coffee phenology, and environmental factors.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Infestation Biology and Life History of CBB: New Discoveries

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A major principle of pest management is to break the life cycle of the insect pest. The optimal time for doing this is usually when host material is limited. In the case of coffee berry borer, this corresponds to the period of time after the coffee harvest has ended (generally December) and before berries on the new crop are pea size or larger (generally March or April of the following year). Coffee berry borer adults can live for months without food in berries on the ground or in "raisins" (dried-up dark brown berries) still attached to the tree. To investigate the population dynamics of CBB, we counted adult beetles in raisins collected in late February from coffee trees on seven Kona farms during the period when green and ripe berries were not present. The average number of beetles per raisin per farm varied from 0 to 24, with an average across all farms of about 7 beetles per berry. Overall, these data demonstrated that raisins are an important reservoir of the pest. We also monitored population growth of beetles in heavily infested ripe berries placed on the ground under coffee trees either on bare ground or within a ground cover of either perennial peanut (one upper-elevational farm) or St. Augustine's grass (one lower-elevational farm). Berry samples placed on the ground were collected every week and dissected in the laboratory, counting all life stages. The results from the low-elevation farm demonstrated that CBB adults were found in the berries through the 10-week study period. These adults reproduced well in the berries within the grass, but reproduction dropped off significantly after the first four weeks. Reproduction was slight for berries placed on bare ground until the 6th week, at which time reproduction became high in all berries, whether these berries were within grass or on bare ground. Reproduction measured from week 6 to week 10 was much higher on bare soil, a reversal from the first four weeks. This corresponded with an influx of adults which presumably were unable to find suitable hosts elsewhere at this late stage of harvest. Presumably solar intensity was also lower starting at week 6, due to the time of year. At the upper-elevational site, reproduction was very high for the first four weeks both in berries on bare soil and in berries within the perennial peanut groundcover. After the first four weeks, reproduction was much higher in berries on bare soil. I concluded that both raisins on the trees and berries on the ground are important as persistent reservoirs and reproductive resources for beetles during the time that host material is in short supply, and that ground cover can enhance reproduction but also shorten the period of time during which berries are suitable for this purpose. Good sanitation (which includes complete and thorough harvesting and not dropping berries on the ground while picking) is hypothesized to be an extremely important factor affecting within-farm migration to the new crop in March and April. Additional research is planned on the fate of beetles in berries on bare soil and within ground cover.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Coffee Berry Borer (CBB), *Hypothenemus hampei* Ferrari (Coleoptera: Scolytidae)–Microbial Interactions

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Bacterial symbionts are frequently associated with arthropods and may play essential or significant roles in host survival, reproduction, and metabolism. They may affect hosts' biology and phenotypes via provision of vital nutrients, breaking down food materials, influencing host plant usage, and mediating interactions with natural enemies. A previous study conducted by Vega et al. positively identified a maternally inherited intracellular proteobacteium, *Wolbachia,* from CBB in Benin, Brazil, Colombia, Ecuador, El Salvador, Honduras, India, Kenya, Mexico, Nicaragua, and Uganda. The study conducted by Ceja-Navarro et al. in 2015 demonstrated *Pseudomonas* species found in the gut of CBB were responsible for mediating caffeine detoxification in the CBB's system. Thus although CBB associations with various bacterial species were detected in previous studies, the functions and roles of the bacterial symbionts in the biology of CBB have been understudied. The goal of this study is to detect and characterize bacterial endosymbionts associated with CBB to the species level, and to elucidate the interactions of selected taxa with the beetle.

Samples of CBB were collected from 36 farms in the Kona and Kā'ū areas of Hawai'i, and Waialua, O'ahu, and subjected to DNA extraction. We used the Illumina Miseq® platform to sequence bacterial populations in/on CBB targeting the V3 and V4 regions of the bacterial 16SrRNA gene. Sequence data were clustered into operational taxonomic units (OTU) at the 97% level by using Illumina BaseSpace 16S pipeline. Greengenes database yielded homologies with 2,337 species among 761 genera of bacteria associated with CBB. Bacterial species found frequently in our samples were from the Gamma and Alpha class of proteobacteria. Small fractions of bacteria detected (approximately 1–3%) were from Clostritridia, Actinobacteria, Betaproteobacteria, and Bacilli. The most abundant genera of bacteria found in our samples were Erwinia, Enterobacter, and Corynebacterium. Out of 23 species of Burkholderia detected in our samples, 7 species were *Burkholderia cepacia* complex that suppress growth of *B. bassiana* in leaf cutter ants, *Atta sexdens. Wolbachia pipensis* was found from 13 locations. Further analysis done by Principal Coordinate Analysis and Hierarchal Dendrogram analysis revealed geographical patterns in bacterial community structure and abundance.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: CBB in Kona as Experienced by Greenwell Farms, Inc.

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The coffee berry borer (CBB) infestation on the Big Island of Hawai'i has had a significant impact on the coffee industry. The overall increase in insect damage in green bean has affected the industry's ability to produce the high quality that Hawaiian coffees have been known for. This short presentation is meant to provide insight into the experience of one particular grower, Greenwell Farms.

Coffee farmers in Kona and other parts of the Big Island are taking steps towards controlling CBB in the field. The average level of insect damage in cherry delivered to Greenwell Farms has dropped from over 18 percent in 2012/13 to 11.6 percent this past coffee season. This significant overall improvement, however, is not enough to overcome CBB's impact to the green bean grades achievable, since minor insect damage does NOT affect the overall density of the coffee beans so that separation can be achieved using traditional grading tables.

Greenwell Farms has invested in optical sorting technology capable of removing green beans with minor insect damage from the process stream AFTER the grading table. This has allowed the company to once again produce upper grades of green bean. However, the existence of CBB in coffee cherry delivered to Greenwell Farms has greatly reduced the amount of coffee that can be converted into grades of Kona Prime or higher. Before the CBB epidemic, the long-term conversion of cherry to green of grade Prime or higher was 5.49 to one. This past season, the company's conversion rate was 6.9 to one, which is the best conversion rate experienced by Greenwell Farms since CBB came to Kona. The result is that the cost to procure and produce green bean of grade Prime or higher has increased significantly.

Unless the coffee industry invests in more optical sorting capacity, the upper grades of green bean simply cannot be produced from coffee cherry grown in Hawai'i origins with CBB. This is because there are approximately 1500 beans in a 300-gram sample of green bean. If one can assume that the ONLY defect in coffee is minor insect damage, the total number of beans that can have minor insect damage would be 80 beans for Extra Fancy, 120 beans for Fancy, and 180 beans for Number 1.[1] These amounts represent 5%, 8% and 12% of the coffee under the current standard.

However, minor insect damage is NOT the only defect in coffee. This means that these upper grades are practically impossible to achieve with the current level of CBB control in Kona unless optical sorting is implemented. Smaller optical sorting machines are available and should be considered by coffee producers in Hawai'i.

The complete presentation may be viewed and downloaded by clicking here.

[1] Current Hawai'i green bean standards allow 10 beans with minor insect damage to 1 full defect count. This provision is scheduled to be changed to 5 to one in July of 2017.

Abstract: Decision Tree Analysis of Coffee Berry Borer in Hawai'i

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After the arrival of coffee berry borer (CBB) in Hawai'i in 2010, integrated pest management strategies were adopted to combat this invasive pest of the Hawai'i coffee crop. A decision tree framework is used to develop a model for management strategies described in the CBB Integrated Pest Management recommendations (Kawabata et al. 2015), for potential use by growers and to assist in developing and evaluating management strategies and policies. The use of a decision tree can be an effective method for understanding integrated pest-management solutions. The model focuses on pesticide spraying (spray/no spray) as the most significant activity. Two results of the analysis suggest that with a high level of initial infestation, it is important to always spray; however, when this initial infestation level is lowered, the farmer will have a higher final net benefit. Furthermore, the results of the subsidy analysis show that a typical farmer is receiving a positive net benefit of $947.17, which might be increased by the ability to spray more often. The results of the sensitivity analysis provide support for the robustness of the model as well as the importance of a low initial infestation level vis-à-vis any level of subsidy.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Sampling Strategies and Monitoring for IPM Decision-Making

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The ability to effectively characterize a pest population and the damage inflicted by that population is essential in making pest-management decisions and for tracking pest populations over time or relative to management actions. We describe the data and analyses required to develop effective, accurate, labor-optimized sampling methods for field use by growers. The relationship between management decision-making and insect distribution within crops, population density, and economic damage levels will be discussed. We will discuss potential alternatives to the 30 Trees method currently in use, with comparative data from Big Island coffee farms. The current method, despite probably being accurate and effective, is considered to be extremely labor intensive. This may hamper adoption by growers. Our research will develop and validate optimized sampling procedures for decision-making purposes.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Coffee Detection, Spatial Assessment, and Modeling

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One of the major challenges facing coffee berry borer (CBB) management on Hawai‘i Island is the high variability of environmental conditions across the coffee-growing region. A single management scheme over such a heterogeneous area might be ineffective in some places and inefficient in others. We have used remote sensing, GIS, and traditional field data collection to 1) locate coffee-growing areas; 2) localize data on weather conditions, CBB infestations, and coffee plant development; and 3) model the populations of the plant and pest. I will present the current status of our coffee-detection ability via spectral and texture analysis of satellite imagery, a brief overview of our modeling approach, and information on field data being collected to test the model. Tools developed here will be useful to other coffee-growing regions in Hawai‘i and around the world.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: *Beauveria bassiana* GHA Persistence in the Environment

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Beauveria bassiana is the most important natural enemy of CBB. Although research on this fungal pathogen has been carried out in other countries, results are variable due to differences among strains of *B. bassiana* and environmental conditions. Much of the research for mitigation and management of CBB in the Kona coffee-growing region of Hawai'i Island has gone into assessing the effectiveness of commercially available *B. bassiana* GHA (BotaniGard®) applied as recommended by University of Hawai'i Extension. From 2014 to the present, *B. bassiana* GHA has been applied at the standard rate (32 oz + 8 oz surfactant in 30 gal of water/acre), and the applied materials have been evaluated for both efficacy and persistence across an altitudinal gradient to assess how the materials work under varying environmental conditions. As altitude varied, both temperature and rainfall differences were found to alter the overall effectiveness of the *B. bassiana* GHA over a multiple-year study period. In short, well-timed applications of *B. bassiana* GHA (both monthly and bi-weekly sprays) targeting flushes of new berries provided reasonable levels of control at both high and low altitudes. Monthly sprays seemed to provide nearly as effective control as sprays applied at shorter intervals, primarily due to the long period of exposure (adult time spent in A/B position), while residual *B. bassiana* GHA inoculum or horizontal transmission helped to protect the crop between sprays. Treatment demonstrations resulted in CBB-damaged coffee beans (adults in C/D position) held to levels below 10% infestation for most of the season, even though attack rates (adults in A/B position) were often greater than 50% at the start of the season. Bi-weekly applications were also effective, but not significantly more so than monthly applications. Monthly *B. bassiana* applications were less effective late in the season after emergence of the next generation of CBB (when maturing coffee berries are vulnerable to rapid penetration). Combining monthly *B. bassiana* GHA spray applications with strip-picking was found to be the most effective treatment tested. Persistence and efficacy data, along with environmental data such as temperature, % relative humidity, UV radiation, leaf wetness, and rainfall, have been collected from all field study locations and are being used to improve CBB management and strengthen the prediction model being developed by Dr. Nicholas Manoukis, ARS. Overall, environmental, persistence, and efficacy results indicate that each location is unique, making it difficult to recommend a "one-size-fits-all" spray regime. Monitoring and assessing infestation levels as a trigger for *B. bassiana* GHA sprays should be continued as the standard means of CBB control.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: *Beauveria bassiana* Application Strategies and Effectiveness

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CBB infestations were sampled on high- vs. low-elevation farms (Smithfarms and Onaka Farms, respectively) in South Kona on Hawai'i Island during March–May 2015 to determine levels of control achieved by applications of the *Beauveria bassiana* (Bb) strain GHA-based biopesticide BotaniGard®. Fields were strip-picked prior to initiation of the spray programs. Applications were made at the approximate rate of 32 oz. BotaniGard ES + 8 oz. surfactant in 30 gal water per acre. Two treatment programs were tested: monthly calendar sprays vs. sprays "as needed" based on an action threshold of 20% infestation. In high-elevation fields treated monthly, cumulative mortality of founder female CBB infesting small, green berries reached a maximum of 60%. In low-elevation fields apparently isolated from CBB migration, mortality reached nearly 70%. Mortality levels at the end of the monitoring period (late May) in fields that received two sprays were an average of 15 percentage points lower than in fields that received three monthly sprays (43 vs. 58%), suggesting that a lower action threshold may be called for. These observations were made with the caveat that the proportion of beetles succumbing to infections by naturally occurring strains of Bb was unknown. In 2015 we determined that the feral strains were readily distinguishable from commercial strain GHA based on gross colony morphology on common mycological media. Genetic characterizations indicated > 95% accuracy of determinations based on this criterion. It was further determined that many of the most prevalent Bb strains infecting CBB in Hawai'i are genetically similar to those that were isolated from diverse insects prior to the CBB outbreak, supporting a conclusion that these strains are indigenous to Hawai'i or at least longtime residents of the state. Weekly sampling of live CBB was initiated at varying times pre- and post-spray application, and the collected beetles were surface-sterilized and held in the laboratory to determine levels of pre-mortem infection (an approximate measure of weekly disease incidence). Average rates of new Bb infections across elevations peaked at 25–35% 2–3 days following application and declined to < 10% within 6–10 days. Lower peak levels of infection (10–15%) were observed when coffee was under heavy attack by migrating (untreated) CBB. Prior to the first sprays of the season, indigenous strains were identified as the dominant types infecting CBB (75% of all Bb infections at low elevation and 67% at high elevation). Strain GHA was overwhelmingly dominant immediately following application, producing virtually 100% of all new Bb infections at low elevation and 88% at high elevation. Over the subsequent three weeks, the proportion of feral strains gradually increased to just 5% under dry conditions at low elevation but to 35% under wetter conditions at high elevation. These observations suggest that the indigenous strains have greater natural epizootic potential (and thus greater long-term persistence) in CBB populations than commercial strain GHA. However, weekly incidence of infection of adult female CBB by the feral strains never exceeded 5%, indicating these pathogens play only a minor role in natural suppression of CBB populations in cultivated coffee. Despite having lower epizootic potential, strain GHA has exhibited virulence greater than or equal to the feral strains when applied as a biopesticide spray under laboratory conditions.

This paper reports results of research only. Mention of a proprietary product does not constitute a recommendation or endorsement of its use by the U.S. Department of Agriculture.

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Abstract: *B. bassiana* and CBB in Puerto Rico: Genetic Diversity of a Natural Epizootic

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The generalist fungal entomopathogen *Beauveria bassiana* (Bb) is a conspicuous natural enemy of coffee berry borer (CBB). A key element in ongoing efforts to control CBB using the Bb mycoinsecticide Mycotrol® is to determine the relative importance of Mycotrol® and indigenous Bb in suppressing CBB populations. In particular, it is important to 1) determine the effectiveness of Mycotrol® to initiate and sustain CBB epizootics relative to that provided by native strains, 2) to determine the environmental persistence of Mycotrol®, and 3) to assess its risk potential to non-target arthropods. In this talk I will describe molecular epidemiological tools used for phylogenetic and population genetic characterization of Bb isolated from CBB at coffee farms in Puerto Rico. In Puerto Rico, all Bb isolations (>200 isolates sampled) are members of a distinct cryptic species of Bb, designated A2, which was the predominant Bb pathogen of CBB in an earlier survey covering Central/South America and western equatorial Africa. Thus, A2 appears to have a special affinity for CBB. Despite prior applications of Mycotrol® at several farms 2 years previous to our sampling, this strain was rarely isolated, either indicating relatively weak persistence of Mycotrol® in this environment or perhaps the inability to compete on CBB against indigenous isolates. A multi-locus microsatellite genotyping system is developed that enables precise discrimination of the Mycotrol strain from indigenous A2 strains and the ability to track the many A2 genotypes associated with the CBB epizootic in Puerto Rico.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Controlling Coffee Berry Borer on a Microscale

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Coffee farmers have asked many questions about effective control of coffee berry borer (CBB) using Organa Agriculture Hawaii, Inc.'s Beneficial Active Micro-Organisms (BAM) product, the effect of feral and unmanaged coffee, and if CBB control using *Beauveria bassiana* strain GHA is possible on small farm plots. A microscale field-based experiment was established to try to answer these questions. The UH-CTAHR 2015 CBB IPM recommendations were followed, with the only variable being the product sprayed on the trees. Significant differences were found between all treatments; however, only *B. bassiana* would provide farmers with a low enough infestation rate to provide maximum profit.

An update about the HDOA *Beauveria* subsidy program will also be provided.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Pruning and Plant Growth Regulator Research

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Field sanitation is essential for CBB control since the life cycle of the CBB can be completed within the protected confines of the coffee berry between coffee seasons. Removing coffee berries by stripping green coffee berries between seasons is recommended for coffee farmers to reduce the CBB population for the start of the coffee season. Stripping green coffee berries at the end of the season is lost income for the farmer. Since Hawai‘i does not have a distinct wet and dry season, each rainfall results in multiple flowering events in one coffee season, resulting in the need for multiple small harvests. This often extends the coffee harvest season. This increases labor costs in hand-harvested coffee and decreases yield of marketable coffee in both mechanically and hand-harvested coffee fields by increasing the amount of green coffee berries at the end of or during the coffee season.

Here we use plant growth regulators to concentrate coffee flowering, combining small multiple flowerings into one larger flowering, by utilizing a combination of commercial products with GA_3 (gibberellic acid) and ABA. Over the last four years, we have optimized growth-regulator concentration and application in hand-harvested fields in Kona. Larger-scale field trials were conducted over the past three years under a Special Local Needs (SLN) permit, and we are working with manufacturers to add coffee to the label of the plant growth regulators. Both products are currently available as OMRI (Organic Materials Review Institute) certified and can be used for conventional and organic coffee farms. Results over multiple years have shown that the treatments successfully promoted flowering of coffee to increase the amount of coffee berries in earlier harvests and reduced the amount of green coffee berries at the end of the season.

The complete presentation may be viewed and downloaded by clicking here.

Abstract: Flat Bark Beetle Predators Research Update

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Adult flat bark beetles, mainly *Leptophloeus* sp. (75%) and *Cathartus quadricollis* (21%) (Coleoptera: Laemophloeidae and Silvanidae, respectively), were found feeding in CBB-infested coffee beans on the tree, and molecular marker studies confirmed feeding on CBB. Research was conducted to better understand the ecology of these predators and explore ways to increase their role in suppressing CBB populations in coffee. Laboratory feeding assays demonstrated the capacity for adult and larval flat bark beetles to feed on all CBB life stages. The predators are widely distributed in the coffee-growing areas on the island of Hawai'i but feed mainly in dried coffee on the tree rather than in ripening cherry where initial crop damage occurs. Berlese funnel extraction of flat bark beetles from dried beans on the tree indicated that predator numbers can be high (up to 23 adult predators per 150-bean sample). The predators are not susceptible to the fungal biopesticide *Beauveria bassiana* used for field control of CBB in coffee. *Leptophloeus* sp. and *C. quadricollis* can be raised on a cracked corn–cornmeal diet. A raise-and-release program was started with *C. quadricollis* by providing farmers with a predator starter kit, and 250 kits were distributed to coffee farmers. Flat bark beetle predators have also been found in high numbers inside the fruiting structures of other plants in the Kona coffee landscape such as koa haole, monkeypod, ice cream bean, and macadamia nut, where they are probably feeding on assorted bark beetles and other insects and on fungi.

The complete presentation may be viewed and downloaded by clicking here.