



Recommendations for Coffee Berry Borer Integrated Pest Management in Hawai'i 2015

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The following document is a collaborative effort between the University of Hawai'i at Mānoa College of Tropical Agriculture and Human Resources, Hawai'i Department of Agriculture, United States Department of Agriculture Agricultural Research Service Daniel K. Inouye Pacific Basin Agricultural Research Center, and coffee grower groups. There is much information, some of it conflicting, on how to control the Coffee Berry Borer (CBB). In 2013, the first CBB Summit was held so those who are investigating control methods could provide industry with a single set of recommendations that synthesize and incorporate the best available information. Participants recognized that recommendations could change as new information becomes available, so they agreed to meet on a regular basis to update the information.

The results of the 2014 CBB Summit are outlined here. This summit again brought together researchers so that the best available information could be consolidated and transferred to growers. Our goal in drafting these recommendations is to provide farmers with up-to-date general guidelines to better manage coffee berry borer in Hawai'i. Foreign coffee-producing regions have proven that no single approach will control CBB. Not all recommendations will apply to all farmers, but we recommend following an integrated pest management approach, using as many of the suggestions—in the order listed—as possible for maximum effect. Reducing CBB levels and keeping population levels low are key to effective CBB management. This document starts with field sanitation, the most important step in reducing CBB population,

followed by recommendations for the rest of the crop cycle: pruning, field monitoring and sampling, pesticide application, harvesting, and shipping. This document does not include an economic analysis of the recommendations. Producers should decide the most cost-effective methods for their farms using available information and business/financial records. For further CBB information, including local and international literature, please visit hawaiicoffee.weebly.com.

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SECTION I: FIELD SANITATION

Field sanitation and strip-picking at the end of the harvest season, regardless of CBB infestation level, are the **MOST IMPORTANT** CBB-control activities. Strip-picking physically removes CBB, and the population is immediately reduced. Strip-picking is a proactive approach that all coffee farmers in Hawai'i should apply.

A. COFFEE CHERRY AND RAISIN

1. *How and when do I strip-pick my coffee?*

- Strip-pick all (green, red, over-ripe, and raisin) cherry prior to flowering and/or pruning.
 - Do not allow cherry to fall to the ground or remain on trees or pruned branches.
 - Remaining cherry and raisins are potential breeding sites for CBB.
- Process or destroy all coffee from this picking.
- If you have continuous, year-round harvesting, strip-pick after the peak harvest season.

2. *How do I dispose of CBB-infested cherry?*

CBB-infested cherry must be disposed of to prevent re-infestation of your coffee farm. Leave buckets or bags with strip-picked cherry in the sun for at least two weeks. CBB may be killed by heat, starvation, other factors, or a combination. If it takes longer for the CBB to die off, keep the cherry bagged or bucketed longer! CBB can chew through plastic bags, so if you are using bags, use thick ones. Elsewhere, burying infested cherry is recommended, but this may not be a viable option for farms with rocky soil.

- Completely enclose CBB-infested cherry in containers or bags.
 - Use heavy-duty, industrial-strength black trash bags or double-bag regular black bags.
 - Buckets or drums with lids can be used to contain and kill CBB, and they can be reused. Do not reuse any container that previously contained pesticides; this is a federal violation.
 - If using burlap bags, place a trash bag inside and then tie it tightly to prevent tearing of the trash bag and escape of CBB through the burlap weave.
 - Leave bags in direct sunlight for at least 2 weeks.

- Adding water to bags or buckets before closing them up may help kill adult CBB.
- You can also bury infested cherries under at least 6 inches of compact soil, or
 - Compost infested cherry with cherry skins.
 - Cover the pile with a tarp and secure the edges.
 - Small amounts of infested cherry may be frozen for at least 48 hours to kill CBB.
 - Once CBB are killed, return cherry to the field, use as compost, or dispose of in an appropriate manner.
 - Although burning is not recommended for CBB control, an agricultural burn permit may be obtained from and submitted to the Dept. of Health's Clean Air Branch for "fires for prevention or control of disease or pests."
 - Rules and regulations must be followed, or you risk citation.

B. PRUNING

Stump pruning by block is the only viable method for establishing a large area without CBB food or shelter. Traditional Kona-style and Beaumont-Fukunaga pruning by rows are not control methods for CBB and do not kill CBB. However, any type of pruning can help to make other activities easier or more effective (e.g., stripping and harvesting more easily, achieving better spray coverage, etc.)

- Prune trees **AFTER** strip-picking all (green, red, over-ripe, and raisin) cherry.
- Stump pruning in blocks or areas may control CBB infestations within an orchard.
 - Avoid stump pruning during drought. Trees need rainfall or irrigation to recover.
 - If you must stump prune during a drought, retain a "nurse vertical" to reduce tree shock and losses from stumping.

If not actively farming coffee, consider stump pruning your coffee trees to control CBB and help neighboring farms in their attempts to control CBB infestation.

SECTION II: FIELD MONITORING

Field sampling and monitoring can incorporate the use of the "Thirty Trees Sampling Method," traps, visual monitoring, or a combination of these methods to help

determine the most effective times to spray as well as the potential effectiveness of spraying for CBB. Several times throughout the year CBB activity may increase, so intermittent sampling may miss significant CBB movement. Year-round monitoring can lead to a better understanding of your operation and help assess beetle activity.

A. RECORD-KEEPING

Noting major farm events, such as your first and main flowering; spray dates, times and rates; harvesting; pruning dates and descriptions; etc. on a calendar or notebook for your individual farm(s) is highly recommended. Recordkeeping of all farm activities and major observations makes activities like spraying, fertilizing, sampling, etc. easier to schedule, organize, and accomplish. As a result, the farmer may gain a better understanding of their farm, farm needs, and CBB behavior in their orchard.

B. SAMPLING

In August 2012, Luis Aristizábal presented the “Thirty Trees Method for Monitoring and Control” to Kona and Kā‘ū coffee farmers. This method has been revised to more accurately suit the needs of coffee farmers in Hawai‘i and to address questions about the specific sample size per area being sampled. Individual farmers may need to make changes based on their particular situation and needs.

1. Why, when, and how do I sample and monitor for CBB?

Early detection of CBB and well-timed sprays will help to reduce infestations before populations explode. Although sampling is vital to determining spray intervals and locations of “hot spots,” sanitation is by far the most important early control method.

- Follow the revised “Thirty Trees Sampling Method for CBB Monitoring - 2014” (see Appendix A) to determine CBB activity, position of CBB in the berries, and infestation percentage.
- Begin monitoring as early as 30 days after the first flowering or as soon as there is an increase in CBB activity, as indicated by trap catch or visual observations.

- Start date of sampling and monitoring will be dependent on your farm location and the flowering habit of your trees.
- Year-round flowering may require year-round sampling and monitoring.
- Sample and monitor at least every 2 weeks at the beginning of the season and if CBB activity increases, and at least once a month thereafter.
- Record everything in a calendar.

2. How do I determine the time to spray Beauveria?

- The Cenicafé threshold is 5% CBB infestation when timing *Beauveria* sprays.
 - Hawai‘i growers may need to consider a lower cherry infestation threshold levels due to smaller farm sizes, higher costs, and individual “break-even” points.
 - A “break-even” point may be determined through a cost-of-production analysis for individual farms.
- This threshold includes the AB to CD ratio, which relates to the position of CBB in the cherry (see Appendix A) and the percentage of infected green cherry.
- Spray CBB when they are in the AB position and are vulnerable to *Beauveria*.
- If you have a high CD proportion, spraying and monitoring intervals may be too large.
- Use mortality rates to calculate and track the effectiveness of spraying.

C. TRAPS

Traps will not control or eradicate CBB but can be used as a monitoring tool to determine when CBB may be vulnerable to spraying and to help indicate when to start sampling. Visual inspection or sampling (e.g., the “Thirty Trees Sampling Method – 2014”) is better than trapping for detection, determining infestation estimates, and finding “hot spots” because traps may not catch CBB until populations are high. Trapping is optional if you are using other means of monitoring CBB activity. Dozens of insects may be attracted to the traps, and other virtually identical beetles may skew numbers (e.g., tropical nut borer from macadamia nut trees). If used, trapping should be part of a program that includes visual inspection and sampling of coffee

cherry on your trees to verify catch. Trap catch does not indicate level of infestation.

1. *How to best use traps for monitoring?*

- At a minimum, start trapping immediately after the harvest season.
- Verify trap catch increases by sampling cherry or visual survey before spraying *Beauveria*.

2. *Which trap should I use?*

Homemade traps with inward-facing flaps and commercial broca traps are equally effective.

- Cleaning at least yearly and painting traps may help to extend life.
- Trap color does not matter, but visible colors like red aid in locating traps in the field. While deployed, traps should be supplied with an attractant lure and kill solution at all times.

3. *How many traps per acre do I use?*

As few as 5 traps per acre can help as a tool for monitoring CBB activity; more may increase effectiveness. Use as many traps as you can service without having to sacrifice activities like strip-picking, spraying *Beauveria*, and harvesting.

4. *Where should I put my traps?*

Hang traps on coffee trees, stakes, or poles in the field to monitor CBB activity.

- Hang traps along the farm border to aid in early detection of CBB in previously non-infested fields.
- Once a farm is infested with CBB, distribute traps throughout the farm.
- Hang traps between 2 and 5 feet from the ground; most CBB are trapped at this height.

5. *What should I use to kill CBB in my traps?*

Soapy water is recommended, but traps must be serviced regularly.

- Use a few drops of unscented dish soap per cup of water to break surface tension so CBB cannot crawl out of the cup.
- Insecticidal or pest strips (ex: Hercon® Vaportape™ II) are also allowed in traps.
 - Drainage holes in collection cups keep pest strips from becoming saturated.
 - Toxicants are effective for up to 12 weeks; cutting them in half reduces their effectiveness to 4 weeks.

6. *Which attractant should I use in my traps?*

A mixture of methanol and ethanol is the best available CBB attractant.

- A 1:1 or 3:1 methanol to ethanol solution in a vial with a 2 mm hole, or
- 3:1 methanol to ethanol solution in a disposable pouch.

7. *How often should I be servicing my traps?*

Service traps as often as local conditions dictate.

- Monitor traps for CBB activity at least every 2 weeks.
- Change lures every 4–6 weeks.
- Inspect vials for holes which may allow attractants to leak out or evaporate too quickly.

SECTION III: PESTICIDE APPLICATION

A. SPRAYING *BEAUVERIA*

1. *How and at which rate do I apply Beauveria?*

Before spraying *Beauveria* or any other pesticide, read and follow all label instructions. The label is the law! *Beauveria bassiana* Strain GHA is the active fungal ingredient in the following:

- Botanigard® ES (EPA Reg. No. 82074-1) – conventional
- Botanigard® 22 WP (EPA Reg. No. 82074-2) – conventional, NOT FOR SOIL APPLICATION
- Mycotrol® O (EPA Reg. No. 82074-3) – OMRI™ approved

These are the only *Beauveria* products that are approved for use to spray and kill CBB in coffee orchards. For tree applications:

- Spray coffee trees with 32 ounces (1 quart) of *Beauveria* per acre; **plus**
- Surfactant (Silwet L-77® Surfactant, Widespread® Max, etc.) at rates according to the label; **plus**
- At least 30 gallons of water per acre.
 - Label rates have a range. Consult and follow the product label for application rates prior to mixing.
 - With good agitation, *Beauveria* spores are easily dispersed at lower surfactant rates.
 - At higher surfactant concentrations, there is a risk of phytotoxicity.
- Use as much water as possible per acre, but use all

32 oz. of Botanigard® ES, Botanigard® 22 WP, or Mycotrol® O.

- Spray the entire tree, including the trunk, base of tree, and underside of leaves.
- Spray to wet, but avoid runoff.
- Type of sprayer will determine how much water is needed per acre.
- Tree size, density, and age will also determine gallons of water needed per acre.

2. Should I spray the ground and in rock crevices around infested coffee trees?

While CBB is looking for new host fruits, they often miss their targets, hit the tree, branch, or leaves, and fall to the ground. They may even hit the side of traps and fall to the ground. In addition, fallen or dropped cherry and parchment on the ground may contain live CBB. Spraying *Beauveria* on the ground may help to kill CBB and inoculate the ground with live fungal spores against subsequent infection. This is especially important when there are no berries on the trees, as dropped fruit will be a major source of infestation.

- Botanigard® 22 WP cannot be used for ground application.
- Ground spraying reinforces the need for sanitation but recognizes the challenges of picking up fruit from the ground.
- Ground spraying is not as critical when there is fruit on the trees, as those are bigger sources of CBB.
- According to the label, Botanigard® ES and Mycotrol® O must be applied as a ground application at a rate of 2–8 fluid ounces per 1,000 square feet. This is equivalent to 87.2–348.4 fluid ounces per acre or 2.8–10.8 quarts per acre.
- Add Botanigard® ES or Mycotrol® O and the surfactant to at least 43.6 gallons of water per acre.

3. How often should I spray?

Beauveria spores germinate within 6–9 hours and can penetrate a host within 24 hours. Insects can be killed in 3–10 days depending on the number of spores and insect size. Best *Beauveria* growth occurs at 23–30°C (74–86°F) and will slow above 28°C (83°F).

- Start spraying *Beauveria* when there is mass movement of CBB as indicated by trap catch and verified by visual observations and in-field sampling methods;
- AND when the threshold % of CBB infestation is

attained with CBB in-field sampling methods.

- Spray at least once a month or as often as monitoring and sampling warrants spraying.

4. Can I add other solutions to Beauveria sprays?

Other solutions can be mixed with *Beauveria*, but do not combine any pesticides not labeled for coffee. Fungicides may negatively affect *Beauveria* efficacy. Consult the compatibility chart created by the product's exclusive distributor, BioWorks, Inc., prior to mixing pesticides with Botanigard® ES, Botanigard® 22 WP, or Mycotrol® O. This compatibility chart can be downloaded at <http://www.bioworksinc.com/products/shared/botanigard-es-tank-mix-compatibility.pdf>, or visit www.bioworksinc.com for additional product information.

Also, test any mixed solutions on a small scale for phytotoxic effects, and avoid combining herbicides like RoundUp with *Beauveria* as current studies show a negative effect on spore growth.

5. Spraying tips for growers using Beauveria

- Review and follow all pesticide labels for Botanigard® ES, Botanigard® 22 WP, and Mycotrol® O.
- Spray in the afternoon or evening and on cloudy days, if possible.
 - Beetle activity is most often observed in the afternoon.
 - UV affects spore viability.
 - High humidity helps *Beauveria* activity.
- Avoid spraying during bloom and when bees are actively foraging, as *Beauveria* may affect bees.
 - If spraying must be done during a bloom, spray in the late afternoon.
- Shake Botanigard® ES, Botanigard® 22 WP, and Mycotrol® O bottles vigorously before adding to water to suspend spores.
- Store in a cool, dry place. Avoid storage at temperatures below freezing or above 85°F.
- Use tank mix immediately, and avoid holding spores in water solution for more than 24 hours.
- Provide enough time for leaves to dry after spraying, to avoid rain washing them off.

B. OTHER PESTICIDES APPROVED FOR COFFEE

A list of pesticides and repellants approved for use on coffee can be found in the Summary of Tested Insecti-

cides and Repellents for CBB Control in Coffee – 2014 (see Appendix B). Determinations of efficacy on CBB as a result of scientific research are also provided.

SECTION IV: HARVESTING

A. PRE-HARVEST

1. *Strip-pick cherry before the main harvest*

Often, the first round of coffee harvested will yield very little marketable coffee and is typically of lesser quality than main-round harvested coffee. Avoid leaving these cherry on the trees. If left, CBB from the first round will infest the developing coffee of subsequent rounds.

- The first round of harvest often has a high level of CBB and should be treated as a sanitation strip-pick to get rid of any color-break, ripe, over-ripe, and raisin.
- Pick and process or destroy all fruit from this first-round harvest.

B. HARVEST

1. *Picker training*

Coffee cherry and raisins left on the ground could harbor CBB and become reservoirs of the beetle for the next season. There is a tradeoff between harvesting red only while allowing unripe and raisin cherry to be thrown on the ground, and harvesting all cherry. Coffee farmers should supervise pickers and impress upon them the importance of efficient harvesting and removing all ripe and dropped fruit. Farmers may combine performance goals with economic incentives such as not hiring the picker again, paying for greens and raisins, and hourly pay.

- Avoid discarding green beans or raisins from the picking basket onto the ground.
 - Leave in the picking basket or discard in a separate container.
 - Small amounts may be discarded in a container with soapy water.
- An alternative is adding a sorting stage before processing by hand, or machine sorting.
- Pick up dropped cherry from the ground, if possible.

2. *Harvest interval or frequency*

Interrupt the CBB breeding cycle. Coffee farmers are encouraged to avoid a harvesting interval of more than

a month, which will allow CBB in berries to mature and escape. The tradeoffs between frequent harvesting and the availability of labor are lessened if cherry is harvested when it is at color-break to red as opposed to only red.

- A harvest interval of 2–3 weeks is ideal for CBB control.
- Harvest promptly and as often as possible.
- Avoid an interval length that would allow over-ripe cherry to fall to the ground.

3. *Harvest bags*

When CBB-infested cherry is placed in a bag, often the heat, movement, etc. cause CBB to leave the cherry. If CBB are allowed to escape from the bag, they are transferred back to and around the field. CBB are effectively contained by lining a burlap bag with a plastic bag (on the inside), which does not appear to increase temperature. Macadamia nut bags can be used to contain harvested cherry, but some growers find these bags difficult to move around in the field.

- Tie bags shut at harvest to avoid the escape and reinfestation of CBB in the field.
- Consider using mesh “tents” treated with vegetable oil to cover bags and trap CBB leaving burlap bags.
- Avoid keeping bags in the field in the sun all day.
 - Take bags to the wet mill as soon as possible.
 - Do not move cherry in bags from “hot spots”/infested areas to clean areas within the farm, especially if these bags are not closed or internally lined with a plastic bag.

C. POST-HARVEST

1. *Contain and kill CBB in wet mill*

Processors can take any or several of the following precautions to avoid infesting surrounding coffee or farms without CBB by containing and killing CBB in the wet mill.

- Screen the entire wet mill or portions of it, such as the flotation and fermentation tanks, to keep CBB from escaping.
- Maintain traps in the wet mill.
 - Traps seem to be more effective in enclosed areas.
- Cover skin, pulp, and mucilage piles with a tarp and secure the edges.
- Heat bags to 122°F (50°C) in a solar box and hold at this temperature for 20 minutes.
- Boil bags in water for 5 minutes, or

- Soak bags overnight in soapy water.
 - Boiling or soaking burlap bags in soapy water can also extend the life of the bags.

2. Transportation of CBB to other fields

To prevent CBB from escaping, hitchhiking, and being released back to farms on trucks, tightly tie shut plastic-lined burlap bags, and clean coffee cherry delivery trucks and equipment with soapy water following deliveries and before re-entering the farm.

3. Contain and kill CBB at the dry mill

- Enclose the drying deck with plastic or screen.
 - Dry parchment to at least 11% (10.7%) moisture level.
 - CBB may still be alive within beans at this moisture level, but they do not reproduce and they do not infest adjacent, uninfested beans.
 - CBB flee the beans during storage in chill rooms.
 - Low humidity (50–60%) helps mitigate CBB.
 - The moisture content of green bean should also be at 11%.
 - The mechanical drying process seems to kill CBB, perhaps with a combination of low RH, high temperature, and physical crushing.
 - GrainPro bags are good for storage.
 - Traps and sticky paper may be used in storage rooms to catch CBB escaping from beans in the burlap bags.
- Chemical treatment (fumigation), which must be approved by HDOA and applied by a certified applicator.
 - Cold treatment, which requires that the shipment be exposed to a temperature of 5°F or less for 48 hours, during which time it must be monitored by a Plant Quarantine Inspector. The size of the shipment depends on the port office freezer capacity. No large shipments are allowed.
 - Heat treatment, which consists of removing green beans from the bag, heating them to a temperature of 315°F for at least 5 minutes, and re-containing them in unused bags.
- Inspectors will attach a tag, label, or stamp to indicate the shipment has passed inspection requirements.
 - Transporting coffee plants and plant parts for propagation from Hawai'i Island to a non-infested island requires treatment with an approved pesticide and quarantine and monitoring in a State facility for a period of not less than one year.
 - Failure to comply with quarantine regulations may result in civil penalties and/or fines, and the shipment may be confiscated and destroyed.

SECTION V: SHIPPING

Currently, an intra-island (on-island) quarantine for the Big Island is NOT in effect. However, the Hawai'i Department of Agriculture has placed a quarantine on ALL regulated coffee items, including but not limited to unroasted coffee, coffee plants and plant parts, used coffee bags, and coffee-harvesting equipment shipped from Hawai'i Island and CBB-infested areas of O'ahu to all other uninfested islands and regions on O'ahu.

- Inspection by HDOA Plant Quarantine Inspectors and certain treatments such as fumigation, freezing, or heating are required prior to shipping. ALL regulated items (plants, parts, green beans, and used equipment, etc.) must have a permit issued by the Plant Quarantine Branch before transport is allowed. The permit will state the approved treatments, such as the following:

These recommendations are endorsed by the following groups (listed alphabetically):

CBB Task Force
Hawaii Coffee Association (HCA)
Hawaii Coffee Growers Association (HCGA)
Hawai'i Department of Agriculture (HDOA)
Kā'ū Coffee Growers Cooperative (KCGC)
Kona Coffee Council (KCC)
Kona Coffee Farmers Association (KCFA)
Kona Young Farmers
Maui Coffee Association (MCA)
Palehua Coffee Cooperative
United States Department of Agriculture Agricultural
Research Service Daniel K. Inouye Pacific Basin
Agricultural Research Center
University of Hawai'i at Mānoa College of Tropical
Agriculture and Human Resources

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APPENDIX A

Thirty Trees Sampling Method for CBB Monitoring – 2015

Based on a Presentation by Luis F. Aristizábal (University of Florida)
Revised: January 2013 by CBB Summit Committee

It is not enough to know that your coffee trees are infested with the cherry berry borer. It is also important to understand what the beetle is doing on your farm. In addition, it is important to understand that cherry infestation is not equal to bean damage. This simple sampling method will show you cherry infestation and bean damage levels, but more importantly, it will show whether the beetle is vulnerable to being killed by spray or not. Sampling will also help you determine the effectiveness of your spray program, may reveal hot spots, and will show you the best management strategies for CBB control on your farm.

Begin monitoring and sampling about 30 days after your initial flowering, or sooner if there is an increase in CBB activity, as indicated by trap catch or visual observations. Continue monitoring through the end of the harvest, sampling green berries only. Sample your farm every 2 weeks at the beginning of the season to catch early-season infestations and then monthly thereafter. Sample at least 30 trees per 2.5-acre plot to accord with the Cenicafé method of sampling. For smaller plots, sample a minimum of 12 trees per acre to determine infestation level. A larger tree sampling population may provide a greater representation of the farm.

Individual farmers may need to adapt these protocols based on their particular situation and needs. For example, if your farm is situated on relatively even terrain or within a single microclimate and your trees are of similar age, under similar management practices, etc., a single sample size of 30 trees might be sufficient for a 3-acre plot. Conversely, you may need to subdivide your farm into smaller plots to address different varieties, tree ages, topographies, areas with shade vs. sun, etc.

Materials

- Farm map
- Knife
- Clipboard
- Worksheet
- Pencil/pen
- Permanent marker
- Container with lid or resealable Ziploc® bag
- Flagging tape or ribbon
- Hand lens, magnifying glass, reading glasses, or other vision aids
- Counter or tally counter

Step 1: Monitoring the CBB Infestation

1. Begin monitoring and sampling about 30 days after your initial flowering.
2. Select and draw a map of the coffee plot* to be sampled.

*Plot can be determined by these factors:

- Location, topography, physical features such as roads or gullies
- Orchard age or pruning stage
- Variety
- Kīpuka or microclimate
- Management practices (e.g., mechanization, organic vs. non-organic, pruning, availability of irrigation)

3. Mark a zigzag pattern on the map to follow as you sample.
 - a. At least 12 trees per acre, or
 - b. 30 trees per 2.5-acre plot.

4. Begin sampling at tree #1 close to a corner of the coffee plot, but avoid sampling trees directly on the border.
5. Randomly select a lateral branch in the middle of the tree with at least 45 berries (more is better).
6. Record the total number of green berries on the branch, and
7. Record the number of green berries with visible white *Beauveria* fungus on the branch.
8. Record the number of green berries infested by CBB (cherries with a hole) on the branch.
9. Pick 3–4 CBB-infested green berries (not including those with fungus) from the branch (or nearby branches if you cannot find enough on that branch) and place them in the container or bag.
10. Flag any trees with high numbers of CBB.
11. Move to tree #2 and return to steps 5–10.
12. Repeat these steps until all samples are collected.

Now, take the information collected and make calculations to obtain the percentage of infestation by CBB:

$$\% \text{ infestation} = \frac{\text{Total \# of infested berries}}{\text{Total \# of green berries}} \times 100$$

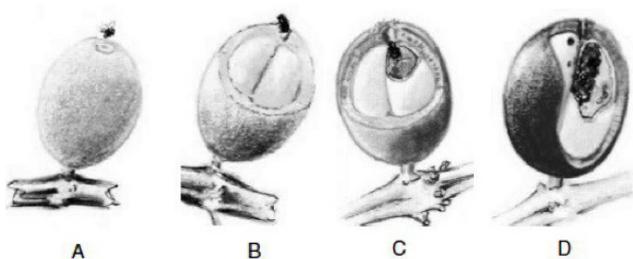
Example: For the 30 coffee branches sampled, we have the following information:

Total # of infested berries = 40

Total # of green berries = 1,500

% infestation = $40 \div 1,500 \times 100 = 2.66\%$

Step 2: Positions of CBB in Berries Used to Determine Whether to Spray



There should be a total of about 100 infested green berries collected in your container. Carefully cut each berry and determine CBB position (AB or CD). Be careful not to kill the beetle while opening the berry, as determining whether the beetle is alive or dead is very important. Record the information on the worksheet provided.

In AB position, the CBB is entering or boring into the fruit, but the endosperm (coffee seed) has not been affected. You should be able to see the back part of the CBB body. In this position the CBB can be killed by natural enemies, weather, or by application of *Beauveria bassiana* or chemical insecticides. A high percentage of CBB alive in the AB position means they are vulnerable and may be controlled by applications of *B. bassiana*, other pesticides, or repellants. Spray as soon as possible. A high percentage of dead in the AB position means your spray is effective.

In CD position (inside the endosperm or coffee seed), CBB are relatively safe. The female and its progeny (larvae) have already damaged the bean. Neither *B. bassiana* nor chemical insecticides can effectively control CBB in this position. In the CD position, CBB may only be controlled by manual collection of ripe and unripe berries. A high percentage of CBB in the CD position means that your spray program was late or ineffective. Consider employing sanitation techniques to physically remove infested berries from the field. Review your spray techniques and program and alter for greater effectiveness.

Step 3: Decision-Making and Timing of Spray

The timing of *Beauveria* sprays may vary greatly from farm to farm. It is better to contain CBB populations early in the season than fight a larger infestation later.

In Colombia, the decision to spray is made when 5% of sampled green berries are infested in the AB position. However, at the value of the Kona crop, this loss from infestation far exceeds the cost of spraying. It is more likely that a 2% infestation in the AB position should trigger a decision to spray.

Thirty Trees Sampling Worksheet: Percent Infestation by CBB

Date: _____ Farm: _____

Plot # or ID: _____ Evaluator: _____

Branch	# of Green Berries	# of Infested Berries	# of Berries w/ <i>B. bassiana</i>
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			
16			
17			
18			
19			
20			
21			
22			
23			
24			
25			
26			
27			
28			
29			
30			
Total			

$$\% \text{ infestation} = \frac{\text{Total \# of infested berries}}{\text{Total \# of green berries}} \times 100 = \boxed{} \%$$

Positions of CBB in Berries Used to Determine When to Spray and to Estimate Bean Damage

Total # of Infested Berries (from worksheet) =

Total # of Green Berries (from worksheet) =

Tally of CBB from Dissected Berries:

AB Alive = CD =

AB Dead = Absent =

Total # of Dissected Berries =

Percent Live CBB in the AB Position for Spray Determination

$$\% \text{ AB infestation} = \frac{\text{AB Alive} \times \text{Total \# of Infested Berries}}{\text{Total \# of Dissected Berries} \times \text{Total \# of Green Berries}} \times 100 = \boxed{} \%$$

Percent Bean Damage

$$\% \text{ CD infestation} = \frac{\text{CD} \times \text{Total \# of Infested Berries}}{\text{Total \# of Dissected Berries} \times \text{Total \# of Green Berries}} \times 100 = \boxed{} \%$$

Observations:

APPENDIX B

Summary of Tested Insecticides and Repellents for CBB Control in Coffee – 2015

Below are research summaries of coffee-approved insecticides and repellents tested by the University of Hawai'i College of Tropical Agriculture and Human Resources (UH CTAHR) for control of coffee berry borer (CBB). All products listed are registered for use on coffee in Hawai'i. Do not use or attempt to use pesticide products on coffee that are not registered for use on coffee and in Hawai'i.

As new research information is forthcoming, there may be new products tested and added to the lists below for CBB control.

PESTICIDE PRECAUTIONS:

- All chemicals and products should be used in accordance with directions on the manufacturer's label.
- Use pesticides safely.
- Read and follow directions on the manufacturer's label.

If you have questions about pesticides or repellents, please contact your local Hawai'i Department of Agriculture (HDOA) Pesticides Branch or UH CTAHR Cooperative Extension Service. Contact information can be found at:

HDOA Pesticides Branch: <http://hdoa.hawaii.gov/pi/pest/pesticide-branch-contacts/>

UH CTAHR Cooperative Extension Service: <http://www.ctahr.hawaii.edu/Site/Locations.aspx>

In case of an emergency, contact your physician or call 911.

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1. Insecticides Tested in Laboratory Bioassays for CBB Control in Coffee, Various

Mike Kawate,¹ Julie Coughlin,¹ James Kam,¹ Andrea Kawabata²

¹UH-Manoa/CTAHR/Plant & Environmental Protection Sciences, ²Tropical Plant & Soil Sciences

All products were tested using maximum labeled rates, assuming a spray volume of 100 gallons per acre. Widespread[®] Max was added to all spray solutions at the rate of 8 fl. oz. per 100 gallons of spray volume.

Product Name	Active Ingredient	EPA Reg. No.	Direct-Contact CBB Control ¹	Indirect-Contact CBB Control ²
Trilogy[®]	Clarified hydrophobic extract of neem oil	70051-2	No	No
Neemix[®] 4.5	Azadirachtin	70051-9	No	No
Prev-Am Ultra	Sodium tetraborohydrate decahydrate	72662-3	No	No
M-Pede[®]	Potassium salts of fatty acids	10163-324	No	No
Movento[®]	Spirotetramat	264-1050	No	No
Provado[®]	Imidacloprid	264-763	Yes	Not tested
PyGanic[®] Crop Protection EC 5.0	Pyrethrins + PBO	1021-1772	Yes	Not tested
EverGreen[®] Crop Protection EC 60-6	Pyrethrins + PBO	1021-1770	Yes	Moderate

¹ Direct Contact: Spray applied directly to CBB female adults.

² Indirect Contact: Coffee berries dipped in spray solution and allowed to dry; CBB female adults then immediately exposed to treated coffee berries.

2. Products Tested In-Field for Repellency and CBB Control in Coffee

Elsie Greco

Formerly with UH-Manoa/CTAHR/Plant & Environmental Protection Sciences

In 2012, Garlic Barrier® AG+ was tested at a rate of 5 fl. oz. per gallon of water plus ¼ teaspoon Silwet®. This spray was applied for 2 days in a row and retained repellency for about 1 week.

In 2013, two products and a combination thereof were tested for CBB repellency and control on coffee. 1) Garlic Barrier® AG+ was tested at a rate of 3 fl. oz. per gallon of water plus 0.08 fl. oz. of Widespread® Max. 2) BotaniGard® ES was tested at a rate of 32 fl. oz. plus 8 fl. oz. of Widespread® Max per acre. Testing was also done on 3) a combination of Garlic Barrier® AG+ (3 fl. oz. per gallon of water plus 0.08 fl. oz. of Widespread® Max) and BotaniGard® ES (32 fl. oz. plus 8 fl. oz. of Widespread® Max per acre). Sprays were applied 3 days in a row and then anywhere from 10 to 44 days after the initial 3 sprays.

Repellency was determined by counting newly infested cherries. CBB mortality was observed and was the result of *Beauveria* infection only.

Product Name	Active Ingredient	EPA Reg. No.	Repellency Control	Direct and Indirect CBB Control
Garlic Barrier® AG+ (insect repellent)	Garlic juice	Exempt	Yes	Direct = Yes, Indirect = No
BotaniGard® ES	<i>Beauveria bassiana</i> strain GHA	82074-1	No	Yes
Garlic Barrier® AG+ and BotaniGard® ES	Garlic juice, <i>Beauveria bassiana</i> strain GHA	Exempt; 82074-1	Yes	Yes

Results showed that Garlic Barrier® has potential as a repellent to reduce CBB attack if used frequently, and it can be used as a component of an integrated program to control CBB. Garlic Barrier®, used alone, did not have an effect on the mortality of CBB. Good coverage and frequent spraying of Garlic Barrier® and other treatments examined are necessary to reduce CBB attack, especially during the rainy season.

3. Products Tested In-Field for Repellency and CBB Control in Coffee

Elsie Greco¹ and Shawn Steiman²

¹Formerly with UH-Manoa/CTAHR/Plant & Environmental Protection Sciences, ²Coffea Consulting

Surround[®] WP was sprayed at a rate of 50 g of Surround[®] WP + 3 ml of Nu Film per 1 liter water every 2 weeks.

- Year 1 (2011) results (kaolin vs. no kaolin) were inconclusive due to the lack of treatment or improper treatment applications.
- Year 2 (2012) results showed promising repellency with Surround[®] WP (kaolin) treatments; however, CBB infestation rates ranged from 5.8% to 53%.
- Only one farm sprayed a combination of Mycotrol[®] O and Surround[®] WP. Compared to the other farms, this farm had the lowest CBB infestation for both years. This combination was most effective at keeping the CBB infestation below 2%. This treatment has the highest cost per application. Mycotrol[®] O was sprayed at a rate of 8 fl. oz. Mycotrol + 4 fl. oz. spreader per 100 gallons water per acre.

CBB mortality was observed and was the result of *Beauveria* infection only.

Product Name	Active Ingredient	EPA Reg. No.	Reduction in CBB Infestation	Direct and Indirect CBB Control
Surround [®] WP (crop protectant)	Kaolin clay	70060-14	Yes	Direct = yes. Indirect was not tested
Mycotrol [®] O	<i>Beauveria bassiana</i> strain GHA	82074-1	Yes	Direct = Yes? Indirect = ?
Surround [®] WP and Mycotrol [®] O	Kaolin clay; <i>Beauveria bassiana</i> strain GHA	Exempt; 82074-1	Yes	Yes

Results showed that Surround[®] WP has potential as a repellent to reduce CBB attack if used properly and frequently, and can be used as a component of an integrated program to control CBB. Good coverage and frequent spraying of Surround[®] WP and other treatments examined are necessary to reduce CBB attack, especially during the rainy season.

Disclaimer

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