Balancing pest risk with cost of control when using *Beauveria bassiana* for Coffee Berry Borer Control

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Coffee berry borer
Hypothenemus hampei (Ferrari, 1867)

- Native to Africa
- Most harmful pest of coffee worldwide
- Affects 70 countries, particularly those in Latin America
- Brazil: 1926
- Guatemala and Mexico: 1970’s
• The growth of the insect (from egg to adult) takes between 24 and 45 days. Female drills the berry through the central disc.
• Two days after the access, the beetle lays 35–50 eggs, which produce ~10 females for each male.
• The lifespan for females is 35–190 days and for males 40 days. The new insects mate inside the seed.
• Newly produced, emigrating females may infest cherries of the same coffee plant, others spread to new plants. Males never leave the fruit.
• There can be three to five generations per season. Up to a hundred beetles can be found in a single fruit.
• The insect is very sensitive to desiccation and waits for the rains to leave the fruit. The most affected areas in the crops are the shady and moist ones.
Coffee Berry Borer Trapping (Eric Jang, Lori Carvalho)

**Trap Types:**

**Scentry 1** = paper trap w/ sloped roof

**Scentry 2** = paper trap w/ flat roof. Developed by Scentry Biologicals, Billings, Montana

**Bucket 1** = one entry window (15cm tall, 15 cm in diameter, 7.5 X 7.5 cm window; red pepper Krylon Fusion spray paint)

**Bucket 3** = three entry windows

**Brocap** = developed by CIRAD and PROCAFE

**New area of research:**

1. Pher- emit dispenser
2. Scentry Sticky traps

Evaluations are on-going
Number of CBB borers caught in 5 milk-jug traps over 7 days (Captain Cook)
Number of CBB caught in 5 milk jug traps per week

- Ethanol/ Methanol
- 0.1% Clove
- 1.0% Clove
- 10% Clove
Without sanitation, coffee berries will always be present in this field.
Gibberellic Acid promotes uniform flowering

Untreated Control Trees

GA₃ Treated Trees
Research on Freezing as a Potential Quarantine Treatment for Green Coffee

1. Cherries frozen for 1-5 days at different temperatures
2. Cherries dissected to determine survival of beetles
3. >15,000 beetle life stages were counted (eggs, larvae, pupae, adults)
4. No survival after exposure to negative 15 degrees C for 48 hours
5. Hawaii Dept. of Agriculture may consider using our data to develop a treatment. As our samples were very small, it is recommended that freezing time for green coffee be longer than 48 hours to ensure all beetles are dead, and the timer should not be started until the warmest part of the coffee gets down to negative 15 degrees.
Biological Controls

• Birds reduce levels of coffee berry borer in Jamaica. Works best in shade.

• *The nematodes Metaparasitylenchus hypothenemi* (Nematoda: Allantonematidae) and *Panagrolaimus* sp. been reported in attacking CBB in the field in Mexico and in India, respectively.

• In laboratory experiments, *Heterorhabditis* sp. and *Steinernema* spp. (including *Steinernema carpocapsae*) have been shown to infect the insect.

Infective juveniles of *Metaparasitylenchus hypothenemi* emerging from an infected coffee berry borer (left), and detail of the infective juvenile (right). Credits: (A) A. Castillo, ECOSUR; (B) G. Nieto, ECOSUR.
Nematodes wiggling after spilling out of dead CBB larva
Entomopathogenic Nematode: 
*Steinernema carpocapsae*

- Roxana Cabos, Robert Hollingsworth, Jessica Manton

Mass-produced by Becker Underwood (product name: Millenium)

Nematodes are mixed with water, sprayed on crops. Commonly used to control caterpillar pests, but also infect CBB (especially larvae) when sprayed onto coffee cherries held at high humidity.

Nematodes go through life cycle in 8 days at 20 degrees C.

Juveniles burst from dead insect and seek out new hosts.

[http://nematode.unl.edu/epn/Scarp.htm](http://nematode.unl.edu/epn/Scarp.htm)

0.25 Billion Nematodes (in 3x5’’ bento container)
First nematode field test was a bust
A second field experiment was more successful

<table>
<thead>
<tr>
<th></th>
<th>Nematodes applied directly to coffee berries (SE)</th>
<th>Nematodes applied to mulch and coffee berries (SE)</th>
<th>Water applied to coffee berries (SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Test 1 - Laboratory</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>26.57% (3.33%)</td>
<td>N/A</td>
<td>1.56% (1.56%)</td>
</tr>
<tr>
<td>Larvae</td>
<td>23.73% (0.96%)</td>
<td>N/A</td>
<td>0.00% (0.00%)</td>
</tr>
<tr>
<td><strong>Test 2 - Field</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adults</td>
<td>6.66% (3.10%)</td>
<td>12.01% (2.54%)</td>
<td>3.82% (3.29%)</td>
</tr>
<tr>
<td>Larvae</td>
<td>18.72% (5.17%)</td>
<td>19.07% (8.13%)</td>
<td>1.25% (1.09%)</td>
</tr>
</tbody>
</table>

Table 1. Percent mortality (SE) in two experiments applying *Steinernema carpocapsae* to *Hypothenemus hampei* in coffee berries
*Beauveria bassiana* is by far the most important entomopathogen for CBB, and considered the most important natural enemy generally.

Beetles killed by *Beauveria bassiana*
**Beauveria bassiana** – what is it?

- A generalist fungal pathogen of insects
- A good soil saprophyte; a weak insect pathogen
- Thousands of strains from around the world represented in entomopathogen collections.
- Commercial products are available
- For most insect pests affected: works well in the lab or greenhouse; frequently does not work in the field. Needs high humidity; broken down by UV light.
- Until February 2011, was not permitted for general use in Hawaii due to quarantine concerns
Does spraying Beauveria (GHA strain) on cherries actually work?

- Lifetable studies suggest that *B. bassiana* is the major biotic mortality factor affecting CBB in Columbia. It’s effect is especially heavy (up to 80% mortality) when CBB are attacking young berries (Duque-O and Baker 2003). There was no previous quantitative field data on effect of GHA strain on CBB, just field observations in Puerto Rico.
- Effects of sprays not easily measured (dissection of cherries is slow and meticulous work)
- There is a lot of naturally occurring *Beauveria* already out there
- May depend on timing of sprays or weather conditions: beetles more exposed in early stages of cherry development
- Spraying *Beauveria* to protect cherries is different from spraying after the cherries have already become infested
Beauveria efficacy trial in heavily infested coffee in Honomalino
Beauveria efficacy trial in heavily infested coffee in Honomalino

Sprayed:

(1) **Mycotrol** (at 1 qt/acre)
+ **EcoSpreader** (silicone spreader),
~350 ml spray solution
(15 seconds) per tree

- Versus -

(2) **Unsprayed**

Harvested cherries the next day.
• Held the cherries in the lab for 7 days, then started dissections

Second and third collections of cherries from same trees made 2 and 3 weeks later; started dissecting the day after collection
Beauveria efficacy trial in heavily infested coffee in Honomalino
Field Plot: farm in Captain Cook

*Beauveria* persistence (Lisa Keith), Strain Identification (Tracie Matsumoto) and Efficacy (Robert Hollingsworth)
Treatment field being sprayed April 25, 2012
Persistence studies

Spray rate = 1.5 qt/acre

10 trees

Spray rate = 1.5 qt/acre

3 trees

Control; “no spray”
Field Sample (Tree 6)

- Lisa Keith

1 sample = 15 berries
5 berries/branch
Laboratory Results - Lisa Keith
Intentional sprays: Treatment side only
Unintentional sprays: Both Treatment and Control portions of field

Days since first Beauveria spray
Goals for Year 2

- Repeat Year 1 field trial

- Test frequency of application (2 sprays versus 4 sprays) and environment (500 ft versus 1500 ft elevation) on efficacy
What does it cost to spray *Beauveria* over one acre of coffee? (estimates)

- 7.0 ounces Beauveria product at $16.50
- 3.5 ounces Silicone Spreader (Widespread, Silwet or Ecospreader) at $4.00
- Labor at $20/hr x 2 hours using backpack: $40.00
- Total minimum cost, one spray: $60.50
- Need at least 4 sprays over the season
- Total cost per acre per year: **Minimum of $242**
Is 7 ounces of Botanigard per acre enough?

1. Picked off all infested berries from selected trees
2. Sprayed individual trees with mist blower
3. Went back at two weeks, collected the infested berries, and determined the percentage of adult beetles with obvious signs of Beauveria infection

Using mist blower to apply water to experimental control trees
Warning: Very preliminary results. Just started collecting data.

**Treatments**

T1 - 10 ml Botanigard + 0.1% EcoSpreader
T2 - 30 ml Botanigard + 0.1% EcoSpreader
T3 - 10 ml Botanigard + 0.1% EcoSpreader + 0.1% EcoSpreader + 0.1% Eugenol
T4 - 10 ml Botanigard + 0.1% EcoSpreader + 0.1% EcoSpreader + 0.5% Caryophyllene
C1 - H₂O Only
C2 - 0.1% EcoSpreader Only

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Week 2</th>
</tr>
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<tbody>
<tr>
<td>T1</td>
<td>18%</td>
</tr>
<tr>
<td>T2</td>
<td>43%</td>
</tr>
<tr>
<td>T3</td>
<td>0%</td>
</tr>
<tr>
<td>T4</td>
<td>20%</td>
</tr>
<tr>
<td>C1</td>
<td>5%</td>
</tr>
<tr>
<td>C2</td>
<td>0%</td>
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Using mist blower to apply water to experimental control trees.
Main control measures for CBB

• Trapping using ethanol/methanol traps
• Spraying *Beauveria bassiana*
• Practicing good sanitation (thorough and frequent picking, not allowing cherries to fall to ground)
• If you had to select just one control measure, which would it be?
To manage existing CBB populations, all mature and dry berries were collected every 2 or 3 weeks over a 2 year period. One additional sanitation pick (‘re-pase’) was made at the end of each major harvest period in each year. No additional control methods were employed. All harvesting was conducted by contract workers, following participatory training exercises in CBB management (Aristizábal et al. 2004).
MONITORING CULTURAL PRACTICES FOR COFFEE BERRY BORER
*HYPOTHENEMUS HAMPEI* (COLEOPTERA: CURCULIONIDAE: SCOLYTINAE) MANAGEMENT IN A SMALL COFFEE FARM IN COLOMBIA

LUIS F. ARISTIZÁBAL, MAURICIO JIMÉNEZ 2, ALEX E. BUSTILLO 3 AND STEVEN P. ARTHURS Mid Florida Research and Education Center, IFAS/University of Florida, Apopka, Florida, 32703, USA
In progress:

- Look at the relative representation of GHA vs "native" Beauveria isolates on coffee berries
- Determine the relative numbers of beetles killed by GHA vs "native" Beauveria isolates
<table>
<thead>
<tr>
<th>Location</th>
<th>Elevation (ft)</th>
<th>Similar to Beauveria Isolated from Host/Country</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2157</td>
<td>CBB/Nicaragua</td>
</tr>
<tr>
<td>2</td>
<td>1775</td>
<td>CBB/Nicaragua</td>
</tr>
<tr>
<td>3</td>
<td>1239</td>
<td>CBB/Nicaragua</td>
</tr>
<tr>
<td>4</td>
<td>2361</td>
<td>NA/Korea</td>
</tr>
<tr>
<td>5</td>
<td>1775</td>
<td>CBB/Nicaragua</td>
</tr>
<tr>
<td>6</td>
<td>1598</td>
<td>CBB/Nicaragua</td>
</tr>
<tr>
<td>7</td>
<td>701</td>
<td>Banana Stemborer/Brazil</td>
</tr>
</tbody>
</table>
What we’ve learned about *B. bassiana*

- Natural *Beauveria* infection is playing an important role in causing mortality of CBB.
- *Beauveria* sprays appear to be helpful but are not a substitute for sanitation.
- Dominant local strains exist – at least at this point in time – and deserve more research.
Jessica Manton

Glenn Asmus

Shannon Costa

John Ross

Fran Calvert and Izabella Zobova