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Experiences using Beauveria biopesticide

Content

Summary assessment of criteria for methods using Beauveria biopesticide

Criteria	**Biological Control based on *Beauveria* fungus biopesticide**
How effective is it in controlling CBB?	Can be useful as part of an IPM strategy IF a good quality product is applied with care and at the right time. 44% of farms interviewed in Colombia and 31% in Central America are currently using *Beauveria* products. 32% of global survey respondents rated biopesticide use *Very Effective* and 37% as *Reasonably Effective* (including in high CBB pressure zones)
How much does it cost?	Not very different from insecticide application cost. *Colombia*: Approx. US$10-37 per application of commercial product per ha + labour. Lowest cost is similar to the cheapest chlorpyrifos product. *Central America*: Approx. US$7-11 per application of semi-commercial product (rice with spores) per ha + labour. Cost similar to or a little less than endosulfan.
How much labour time does it need?	Labour time similar to mixing and applying any insecticide. Semi-commercial products need spores to be washed off rice and filtered before adding to the spray tank. Labour time for monitoring CBB incidence levels and assessing whether borers are within reach of biopesticide contact should also be included.
How easy is it to implement?	Semi-commercial products (rice with spores) have short shelf-life of a few days if unrefrigerated so should be applied as soon as possible and not stored or transported at high temperature. As with insecticides, *Beauveria* applications will not kill borers already within the bean so careful timing of application based on field assessment is needed.

	Semi-commercial products best applied early or late in the day to protect spores from UV light, unless groves are shaded or weather cloudy. Fully commercial products usually contain UV protectants. Fungicides applied close in time to *Beauveria* applications will kill the spores. Separate spray equipment should be used to avoid contamination. Semi-commercial products not widely available and may need to be ordered direct from technical support organisation or farmer co-operative.
Does it need much training before it can be used?	Farmers must understand how applying living fungal spores differs from spraying a chemical. Advice, and preferably an individual or group training session, is needed to explain how to store, use and evaluate *Beauveria* products. Farmers are often best convinced by seeing biopesticide use in practice on an experienced user's farm.
Other key points	Good cultural controls are the backbone of any effective IPM strategy. Biopesticides will not work well or cost-effectively without grove sanitation. Farmers need to understand that *Beauveria* does not immediately kill CBB but takes several days to infect and kill the insect. Regular applications can increase background levels of *Beauveria* in the grove, providing some level of longer-term control, especially in cooler, shady and humid conditions. Some large farms have successfully reduced or replaced chemical use with regular *Beauveria* applications plus improved cultural controls.

Summary of use in production zones with continuous flowering (Colombia)

Table 1. summarises the use by the 9 farmers interviewed in Colombia. Three of them regularly apply biopesticides based on the fungus *Beauveria bassiana* as part of their IPM strategy and two other farmers sometimes use it. Overall, 55% of those interviewed are using biopesticides to some extent. Another 22% have used *Beauveria* in the past but no longer feel the need as good cultural practices keep CBB levels very low. *Beauveria* use tactics vary between the farmers using it each year – one regularly applies it 3 times a year to most of the plots, one focuses on hotspot applications once or twice a year, and another farmer makes ground applications only under older trees.

Estimated cost varies from US$10-37 per application per ha for the product (excluding labour). The lowest cost estimate is similar to one application of the cheapest chlorpyrifos insecticide product.

All users report good or excellent results IF *Beauveria* product is applied at the right time and in conjunction with good monitoring and frequent berry picking and sanitation.

All highlighted that *Beauveria* takes some days to take effect but compared with chemicals it can have a much longer-lasting regulatory effect on CBB, as the fungus becomes established in the groves and reproduces, to infect more borers later. It won't work as an emergency, last minute control tactic.

The fully commercial products used by these Colombian farmers don't have any major shelf-life or sunlight degradation constraints (the products contain protectants against UV light) but some farmers feel they are best applied under cooler conditions early in the morning. One

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important obstacle to effective use of *Beauveria* is application of fungicide for controlling coffee diseases, as the fungicide can kill the *Beauveria* spores. The coffee rust resistant varieties such as Castillo promoted by the National Coffeegrowers Federation and planted by some farmers avoid this problem as they don't need fungicide protection.

Those farmers using *Beauveria* regularly, along with very good cultural controls, have been able to greatly reduce or eliminate insecticide use. Reducing reliance on chemicals is a specific aim for their farms. The generally higher cost per application of *Beauveria* products, compared with insecticides, is not seen as a problem by these farmers because they are motivated personally and via their certification requirements and markets to minimise use of hazardous pesticides and to avoid worker health problems and harm to wildlife. Farmers highlighted that there are gains, sometimes economic, in using safer biopesticides, for example, no cholinesterase testing of spray operators is needed if the farm no longer applies any organophosphate insecticides.

Details of use, dose, costs and farmers' tips and recommendations are given in Appendix A. Label information of products used is in Appendix D.

Table 1. Colombian farm use of *Beauveria* biopesticide

Farm (size)	***Beauveria* use?**
A (small)	Applied in past and gave good results but no longer any need. If neighbours apply endosulfan or other chemicals these can negatively affect the fungus. Sometimes sees naturally-occurring *Beauveria* in grove.
B (small)	Applied in past but no longer any need. Sees naturally-occurring Beauveria in grove, especially in rainy season
C (medium)	Does occasional applications and background levels increased, under well mulched, better shaded and mixed cropping system developed.
D (medium)	Not used in groves but applies to pulp pit.
E (medium)	Not used but naturally occurring *Beauveria* very noticeable in groves.
F (large)	Now uses regularly, 3 foliar applications per year, as part of reducing chemical use.
G (small)	May sometimes apply foliar spray once a year.
H (large)	Now uses regularly, 1 or 2 foliar and ground applications per year on hotspots, as part of reducing chemical use.
I (medium)	Uses regularly for ground application only in older plots, as part of zero insecticide use system.

Summary of use in production zones with defined flowering and one main harvest period (Central America)

Table 2. summarises use by the 13 farmers interviewed in Nicaragua and El Salvador. Six of these farms have applied *Beauveria* in at least one season. Overall, 31% of farmers

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interviewed are currently using *Beauveria* as a regular part of their IPM strategy. One small-scale farmer applied the fungus for the first time in 2013. One estate has tried it but prefers to use chemical, cultural and trapping controls. In addition, one export company includes *Beauveria* use as part of its IPM strategy on its own estates and is now promoting its use among its certified supplier farms.

Beauveria users are applying local semi-commercial products grown on rice substrate by either a co-operative (Nicaraguan cases) or by the national coffee research institute (El Salvadoran cases). The mass of rice grains with fungal spores are sold in packs of 300-500g and the spore mass 'washed' into the spray solution, using fine mesh to prevent the rice grains from entering the spray tank.

The small farmers reported spraying *Beauveria*, when possible, throughout the groves, while the medium farmers have used it in hotspots. Some make only one application per year and others may apply a second spray.

Costs vary from US$7.10-11.34 in product per ha + labour , according to product price and dose rate used. The product cost is similar to, or a little lower than, insecticide use of US$ 9.37-15.62 per 1 ha dose of endosulfan. Most farmers considered the cost very acceptable but one smallholder cannot afford it under the difficult economic situation in 2013.

Two farmers reported very satisfactory results over several years, two others did not know or comment, and one recently applied for the first time so it was too early to judge the results. One estate manager reported that the fungus does work but is not as effective as chemical control.

All those using *Beauveria* explained that they apply it as part of their control strategy, along with good cultural controls and sometimes with trapping too. It cannot be used as a single 'replacement' for endosulfan or other chemicals.

One of the farmers and all those producing and promoting *Beauveria* highlighted the need for farmers to be trained in its use so they understand how this product made from a living fungus differs from a chemical and needs to be handled with care. Short shelf-life of the rice/spores sealed packs (up to 15 days out of refrigeration) was a problem raised by some farmers and organisations in terms of getting more farmers to use these products. They need to apply these semi-commercial products as soon as possible after purchase.

Beauveria spores may be killed by a fungicide application close in time and the biopesticide should not be applied in the same spray equipment as used for fungicides. Conventional farmers using fungicides are not sure that biopesticides are compatible with their practices.

Farmers experienced in using *Beauveria* pointed out that the results are not immediate and it works best to prevent CBB levels increasing or spreading to other groves, in order to protect the future harvest, rather than remedying current infestation. However, they have observed naturally occurring levels increase after use and this helps in longer-term CBB regulation, along with cultural controls.

Farmers' interest in using *Beauveria* is because their farm is organic and no alternative spray options are permitted or they have been encouraged to use it as part of pesticide

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reduction aims for CBB. One noted that, unlike endosulfan, *Beauveria* does not harm the soil microflora, which is important for coffee plant nutrition under organic systems.

These *Beauveria* products are not available in commercial agricultural supply stores and can only be obtained direct from the biopesticide labs or via co-operatives or technical support organisations promoting their use. Effective use is not very likely if these semi-commercial products are sold without proper training and advice.

Table 2. Central American farms' use of Beauveria

Farm (size)	***Beauveria* use?**
A (medium)	Has never used, feels cultural controls sufficient
B (medium)	Has never used, feels cultural controls sufficient
C (small)	Applies once a year, as part of good organic practices
D (small-medium)	Sometimes applies one or two applications, as encouraged by co-op
E (medium)	Has never used
F (small)	Does not apply but has considerable naturally occurring *Beauveria*
G (small-medium)	Applies twice a year as part of CBB control strategy promoted by co-op
H (small)	Applies twice a year
I (large) Uncertified	Has tried but considers chemical control more effective
J (large)	Has never used and content with trapping method recently started
K (small-medium)	Using for the first time this year, as encouraged by co-op
L (medium)	Has never used
M (small-medium)	Has never used

Summary from survey responses (global)

Information on use of biopesticides from respondents was almost exclusively on the fungal agent *Beauveria bassiana*, the most commonly used microbial biocontrol agent used against CBB globally. A powder or other preparation containing the fungal spores is diluted with water and applied as a foliar spray using a conventional knapsack or other sprayer. The fungal spores may be mass produced on rice in a cottage-industry scale unit or purchased as a fully formulated commercial product, the latter now being the more commonly reported. In Mexico, the state agriculture agency has distributed *Beauveria* to coffee growers.

According to respondents to the project survey, effectiveness of this biopesticide method ranges from zero to 'Reasonably Effective' to 'Highly Effective', with roughly equal numbers mentioning each level or not ranking its effectiveness (Appendix E: Table 1). Of 18 responses, 5 consider biopesticides as Highly Effective; 5 as Reasonably Effective; 4 as Not Very or Completely Ineffective; and 4 did not rank their effectiveness. There are issues of (a) obtaining a good quality and well formulated product and (b) ensuring that the biopesticide is

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applied at the correct time to be able to infect the female CBB and at adequate dose rate (sufficient number of spores) to help control the pest. Several respondents stress that using biopesticides is one element of an integrated pest management strategy and is not effective as a 'stand-alone' method.

Only a few details were provided by some respondents on Beauveria application methods or costs (Appendix E: Table 2). More information is probably available in published sources and possibly national organisation IPM recommendations and advice. The number of biopesticide applications mentioned varies from one to five per year but need to be carefully timed to infect CBB adults before they are out of reach inside the developing bean.

The cost of using *Beauveria*, or another biopesticide, includes the purchase price for the product and the labour involved in applying it and the frequency of applications. It is hard to compare costs between countries but responses seem to indicate that the cost is cheap or moderate (Appendix E: Table 3). It is not clear from survey responses to what extent *Beauveria* or other biopesticides are currently being used.

Views of experts consulted and issues for consideration

Dr Peter Baker from CABI Bioscience provided feedback on draft project summaries and to specific questions, based on his lengthy experience working in Colombia and elsewhere on CBB IPM:

- Accurate costs of applying *Beauveria* are lacking. Estimates should include the full cost including spray equipment and its maintenance and labour. Two applications would generally be needed per year in the Colombian context, to target borer attacking berries from the two main flowering peaks.
- Many *Beauveria* products, particularly semi-commercial 'artisanal' ones, simply don't have a high enough concentration of fungal spores to deliver effective CBB control. You should be aiming for around 10^{10} spores per tree. Many only deliver around 10^{8} spores per tree (the spore dose recommended by Colombia's FNC) and the spore concentration and dose rate of some of the applications by interviewed farmers looks rather low. The economic constraint has been that mass producing *Beauveria* to achieve high spore concentration is very costly and the products expensive. [However, another CABI colleague specialising on biopesticide use considers that lower doses can still be useful, if the application is well timed and conducted.]
- There is no real experimental data available to prove the value of spraying *Beauveria*. The cost-effectiveness of *Beauveria* application in Colombia in the past [using poorer quality products available at that time] was never proven at the full costs for a single spray (up to US$100 per ha). In other words, is it worthwhile for farmers to spend money on *Beauveria* applications which might not be effective, rather than on labour for better sanitary controls, for example?
- Farmer observations about the effectiveness of *Beauveria* and comments about the fungus spreading to neighbouring farms need to be taken with caution. *Beauveria* occurs naturally in the soil in all coffee-growing areas and can be observed infecting CBB, especially in favourable weather and micro-climate, sometimes at high infection rate. When farmers express satisfaction at *Beauveria* activity, they may be observing good natural background levels, possibly increased to some extent by their product applications.

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- Positive experiences reported by farmers interviewed may also relate to the fairly low CBB pressure in recent years, with wetter weather increasing background *Beauveria* levels and therefore more CBB natural mortality. More rain also means more rapid rotting of fallen berries and therefore smaller numbers of borer surviving to colonise the following crop.
- Quality control of some biopesticides is still very poor, with certain commercial products [not from Latin America] proven to have zero viability of spores in lab tests. Transport and storage of semi-commercial products with a short shelf-life can be a major difficulty in some regions. Lack of independent quality control can mean products on the market may have widely varying spore survival so farmers don't know what they're really buying.
- There is no real evidence that the fungus *Paecilomyces lilacinus* (one of the biocontrol agents in the MicosPlag ® biopesticide used by one farm interviewed) works against CBB. Human health concerns have been raised recently for this particular fungus because it can cause serious eye infections. Concern is mainly for hospital patients and people in poor health but it seems that infection of healthy individuals can happen too. Individual sensitisation to *Beauveria* spores, leading to allergenic problems, can occur for biopesticide lab workers handling the material on a regular basis, unless good lab hygiene procedures are followed, minimising exposure.

Dr Adán Hernandez and Ms Karla Romero from PROCAFE coffee research institute in El Salvador provided information from their research, production and implementation experience with *Beauveria* semi-commercial product 3B® (see Appendix D too) and in response to specific questions. Karla joined export company COEX in November 2013 to set up their own *Beauveria* production unit and they are planning detailed research with COEX supplier farms to look at the cost-effectiveness of using biopesticides, compared with other IPM methods. Details of PROCAFE research results on CBB mortality from *Beauveria* products are in Dr Hernandez' presentation at the project lessons workshop of Oct 2013.

- *Beauveria* applications should always be based on CBB behaviour in a particular farm and season. Under Central American conditions, the adult females start to attack new berries around 90-100 days after flowering (DAF). From this period until 120 DAF, the borer stays partly exposed outside the berry and this is the appropriate time to target with *Beauveria* (or indeed a chemical). Once inside the bean, the borer is out of reach of any application.
- With products composed of rice with spores, including PROCAFE's 3B® product, packs can be kept for a maximum of 15 days once removed from refrigeration. Packs should not be exposed to full sunlight and should be kept in a cool place during transport and before application.
- A good concentration of spores and appropriate formulation of *Beauveria* product is essential, as well as advice on how to use it effectively. It is important for technical staff to train small farmers how to handle and use these products properly.
- Best practice is to firstly sample to find out % CBB levels and position in the berry. In El Salvador this sampling should be between Apr-Aug to see if *Beauveria* needs to

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be applied (and then to assess if applications have worked). First sampling should be 85-90 days after the first good flowering period.

- If more than 10% of berries are bored, spray *Beauveria* directly (during Jul-Aug usually) and carefully onto the berries themselves (not the foliage). You may need to make a second application if there have been several significant flowerings with berries from those becoming susceptible later.
- Assessing the effect of a *Beauveria* application is easy and very useful. PROCAFE recommend sampling 100 bored berries before application to count: (i) no. live borers, (ii) no. of dead borers, (iii) no. of borers killed/covered with *Beauveria* white 'fluff' and (iv) no. of 'escapees', i.e. berries slightly bored but no borer present. Repeat the same assessment 15-20 days after spraying and the difference can be considered the effectiveness of your application.
- *Beauveria* certainly works noticeably well when there are high borer levels present for it to infect but its application is compatible with all coffee production systems and situations. The important thing is to explain to farmers that it is only one part of an integrated strategy and not a 'magic solution'.
- Many farmers are wedded to the concept of chemical control and it can be hard to convince them of the effectiveness of other methods, especially biological control. They don't consider the pros and cons of insecticide application and often believe that an endosulfan application must have worked, even when plot assessment shows it has not. So they can be very sceptical about *Beauveria* and its usefulness. In countries like El Salvador where endosulfan is still legal, its availability poses a serious obstacle to more farmers adopting IPM methods for CBB.
- Farmers will not stop endosulfan use without good training in the different IPM methods which make up an effective control strategy.

Dr Carmenza Góngora from Cenicafe research institute in Colombia has worked on *Beauveria* (see her presentation at the project lessons workshop for more details):

- Background *Beauveria* levels can provide 10-20% natural CBB control [under favourable grove and weather conditions].
- FNC and Cenicafe recommend using *Beauveria* biopesticides as part of an IPM strategy.
- Cenicafe has measured CBB mortality of 50-60% with different strains of *Beauveria* and mixtures of strains, applied at a concentration of 2 x 10^7 spores per branch.
- *Beauveria* spraying when CBB populations start to fly up from fallen berries to attack new berries can kill some borers immediately and others infected will die later as they penetrate the berry. Any borers infected with the fungus which do survive to penetrate the bean lay 90% fewer eggs than healthy borers.
- *Beauveria* applications are also recommended just before cutting down trees in plots for replanting and again 15 days later, to prevent the CBB population exiting the disturbed berries from colonising neighbouring plots.

Compatibility issues of Beauveria *application on farms using fungicides*

Many conventional farmers apply fungicides to prevent or to control diseases, especially coffee rust (caused by a different fungus). *Beauveria* spores can readily be killed by many

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contact fungicide products, including copper-based ones, if these are made shortly before or after the *Beauveria* application. If farmers are using the same spray equipment for *Beauveria* as for fungicide application, there is a high risk that the equipment will still be contaminated with fungicide traces, even after washing, and therefore affect the performance of the fungus. Farmers want to know if using fungicides is completely incompatible with *Beauveria* use or whether and how they can integrate both methods on their farm.

Adán Hernandez at PROCAFE stresses that fungicide application for rust disease should be carefully timed based on the disease epidemiology. In Central America the best time is at the start of the rainy season (May-Jun) before there is much rust inoculum around. At this stage, developing berries are too small to attract much CBB so use of fungicide for rust prevention should be compatible with later application of *Beauveria* (late Jun-Aug), especially if the fungicide is applied to the foliage and *Beauveria* to the berries. Karla Romero confirms that *Beauveria* use and fungicide use are compatible, as long as there is enough time between the two applications, and she has worked with 2 estates that achieved this successfully.

Peter Baker considers that in the Colombian context, if four preventative fungicide applications (mainly for coffee rust disease) are recommended on foliage during berry development stage when borer attacks, this could be problematic for *Beauveria* use. *Beauveria* applications onto berries on the ground should be feasible, however, and if systemic fungicides only are used [i.e. ones in which the active ingredient is absorbed by the plant tissue from a targeted application to part of the tree or roots] those should not affect *Beauveria* spores.

Carmenza Góngora from Cenicafe confirmed that you do need to avoid fungicide use close to *Beauveria* application, which should be directed onto the berries, while fungicides should be applied onto foliage. The main FNC recommendation now is to use rust-resistant coffee varieties to reduce need to apply much fungicide. Several of the farmers interviewed have successfully replanted portions of their groves with Castillo variety and have not had to apply fungicides.

Suggestions for follow-up:

Try to get more info on control efficacy of the different *Beauveria* products being used by interviewed farms and obtain samples for quality control checking (spore concentration, spore germination rate; contamination).

It would be useful for farmers or support organisations to do some quality testing, to make sure they are using or promoting good quality products.

Longer-term studies with trials on real farms (including those farms reporting good practices and results over several years), would be useful to more properly assess *Beauveria* effectiveness on CBB mortality rate, control levels and its cost/benefit under a range of biophysical, agronomic and economic contexts.

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Appendix A: Details of farmers' *Beauveria* use in Colombia

A.1: La Palmera (large farm, Rainforest & Fairtrade certified, member Anserma co-op). Mr Alfonso Gómez, Farm Manager

Product used: Brocaril® (Laverlam)

Dose rate: 50g product per barrel of 200 litres water. Applies 1.5 barrels per ha, i.e. 75g Brocaril, for 3 year old trees and 2 barrels, i.e. 100g Brocaril, for trees 4-6 years old.

Cost of product: Approx. US$66 per 500g.

Cost per ha application: ~ US$10-13 according to tree age in product + US$21.90 in labour

Comparison with insecticides: Similar or a little more expensive at higher dose on older trees. Cheapest generic chlorpyrifos product costs ~ US$10 per ha, using 3 litres/ha.

Frequency: 3 applications of Brocaril per year.

General or hotspot application: No definite info but interview suggests probably general applications, following plot sampling.

Timing: around 90-120 days after flowering

Application considerations: Brocaril product very resistant to sunlight but best to spray in humid conditions and cooler

Effectiveness: Very good, can wipe out all CBB it reaches. Better than many insecticides if applied just as CBB starts to enter berry.

Beyond direct kill by contact, fungus will spread in the environment and contaminate more CBB. Also exerts very good control on CBB present in any fallen berries. But takes some time to work, maybe 10 days.

Views and perspectives:

- Farm now uses lots of Brocaril and fungus is getting disseminated further in groves. Estimates that farm could end up managing broca insecticide-free, just with Brocaril spraying on top of very good cultural controls.
- Need to understand that Beauveria works differently to chemical products, takes more time but then has a longer-lasting impact as it spreads.
- You can't use it as an emergency, last-minute control.
- Would recommend any farmer to start applying Beauveria well-timed, instead of endosulfan, for immediate control and to build up background levels and kill CBB in fallen berries but effective cultural controls are essential.
- Formerly tried to produce Beauveria on farm but very easily contaminated and it was not cost-effective

A.2: Las Brisas (medium farm, Fairtrade, Utz, Rainforest certified & 4C, member Risaralda co-op). Mr Guillermo Londoño, Owner.

Product used: Brocaril® (Laverlam). Used Conidia® too but found Brocaril is better.

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General or hotspot application: Only on the ground on plots with tall trees (4-5 years old). Will therefore apply to 40% of hectarage each year.

Application considerations: Needs to be sprayed under tree canopy onto the 'plate' around the trunk. With good mulch and ground cover, microclimate under trees is highly favourable for fungus growth. Their tactic is only to use fungus to kill CBB in berries on ground and avoid these infesting berries above.

Effectiveness: Works very well. Their main control strategy is based on careful sampling, cultural controls and intensified controls on identified hotspots. No use of chemical insecticides for several years.

Views and perspectives:

- Don't consider Beauveria costs as very much as it's spraying only the ground on 40% of farm. Brocaril, being an imported product, is more expensive than Colombian biopesticides but they find it works best.
- Biological products need to get established and they work more slowly. It's a question of awareness, being sure about what a biological product will do… You've got to be patient because you won't see the results the next day, nor in one or two weeks later but you'll keep applying and gradually see the fungus getting established and then start seeing the effects.
- Beauveria fungus will spread naturally, even to neighbours' plots. Encouraging several farmers in a zone to all apply fungus at the same time can help a lot to increase natural levels and reduce CBB pressure.
- Fungal use is increasing, even on some large estates, as modern products are better, with more aggressive Beauveria strains, farmers getting more used to it and more promotion by agricultural supply stores, emphasising biological and cultural controls, with chemical insecticide as a last resort.

A.3: La Azulita (small, Fairtrade certified, member Anserma co-op). Mr Rafael Henao, Owner.

Product used: not specified

Dose rate: 1 small bottle per 10 tankfuls

Cost per ha application: approx. US$22 + US$13.70 labour

Frequency: Once a year

General or hotspot application: where needed

Timing: according to CBB incidence info from methanol trap and flowering calendar. Will generally control use ReRe or fungus application, with chemicals as a last resort.

Application considerations: Applying fungus in good time helps you control for future berries.

Effectiveness: If you apply in good time, prevents CBB from boring into beans. Fungus hits its target better on lower branches.

His main tactic is very timely cultural controls, ReRe every 15 days and then making sure any spraying of fungus or chemicals is very carefully timed.

Views and perspectives:

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- Doesn't consider very costly
- Works well in this climate but maybe not in hotter areas.
- If you keep applying, fungus will become established in your groves, becomes easily observable and makes it easier for you to keep good control on CBB mainly with cultural sanitation

A.4: Agrovarsovia Farms (large farm, Utz, Rainforest certified & 4C) Mrs Marlen Sanchez, Internal Auditor, and Mr Arlides Aricapa, 'brocologist' (full-time staff member for CBB control programme)

Product used: MicosPlag (Orius)

MicosPlag contains 3 fungal entomopathogens and used for CBB control. They tank mix with Trichoderma (Orius) biopesticide for disease control.

Dose rate: 150-200g per ha in 300 litres for MicosPlag

Cost of product: US$24.66 per 100g bottle

Cost per ha application: US$36.99 in product + US$35.51 in labour

Comparison with insecticides: More expensive but many benefits

Frequency: usually 2 sprays per year in a plot

General or hotspot application: Hotspots in plots averaging over 2% CBB incidence from weekly monitoring.

Application considerations: Prefer to spray early in the morning (06.00am) to protect fungal agents from sunlight. Can be later in cooler, higher farms.

Effectiveness: Well applied, it will create a population and this will reduce infestation percentage. Make sure to assess effectiveness of control actions by monitoring CBB incidence, mortality after applications

Views and perspectives:

- Advantage is that MicosPlag being a living organism carries on performing long-term, it helps regulate CBB for longer than a chemical. We can see Beauveria growth on affected CBB 4 months after last application.
- Very good experience with MicosPlag and Trichoderma and have greatly reduced chlorpyrifos applications since using biopesticides. Zero use of insecticide achieved in 2013.
- Biological products will only work well if you carry out very good management practices.
- Cost of chemical products is less but you can incur additional costs, e.g. required to test worker cholinesterase levels if using chlorpyrifos under Rainforest certification. Plus need to avoid worker health problems.
- Workers will still use full PPE kit (gloves, mask, boots and liquid-repellent multiuse lightweight tunics, trousers and head covering) when mixing and applying biopesticides

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Appendix B: Details of farmers' *Beauveria* use in Central America

B.1: La Consentida, Nicaragua (small farm, certified organic & Fairtrade, member of local co-op affiliated to PRODECOOP). Mrs. Maritza Colindres, Owner.

Product used: artisanal Beauveria product on rice from PRODECOOP lab, Palacaguina

Dose rate: 2.84 'dose' packs per ha. Pack contains around 300g rice with spores

Cost of product: US$3.95 per pack

Cost per ha application: US$11.34 per ha + labour

Comparison with insecticides: compared with US$ 9.37-15.62 per 1 ha dose of endosulfan [prices obtained from 3 different agrisupply stores, July 2013]

Frequency: Once per year

General or hotspot application: Overall is best, if you can afford it, otherwise on worst affected areas. Beauveria can control CBB attacking bulk of green berries left, after you remove early ripening berries 4-5 months before harvest.

Timing: last week in July or first week in August when CBB is starting to attack growing berries (when the bean is starting to fill). Must apply when CBB is outside the berry or just entering the flesh. Beauveria will not kill CBB once the pest is inside the bean.

Application considerations: According to plot diagnosis. Must apply within 12 hours of the product being taken out of the fridge, otherwise fungus will die. Best to apply when cool and cloudy.

Effectiveness: Very effective if applied at right time. If sprayed at exactly the right time, it can completely prevent bean damage at harvest.

Views and perspectives:

- Many smallholders cannot afford to buy Beauveria this year due to tough economic situation (very low coffee price last year and heavy yield losses due to coffee rust)
- Unlike endosulfan, which gives a visible result within 3 days, Beauveria fungus takes much longer. You may not appreciate full effects until the following season after fungus has been reproducing in the grove. You should see reduced bean damage at harvest the same year.
- Advantage of using Beauveria is that as long as you don't apply other products that might compete with Beauveria, the fungus will develop and persist among the trees, so it helps you to cope with the pest long term.
- Another is that, unlike endosulfan, it will not harm soil life or the beneficial microorganisms that help the plant thrive.
- After several years' application, your background levels of fungus will be higher, helping to control CBB naturally.
- Disadvantage is that farmers must know how to use it, look after it and must apply it correctly, otherwise they're wasting their money. Farmer training and awareness is essential.
- Another disadvantage is that it's not readily available- no conventional agrisupply store in the nearest town stocks it- so you need to obtain from a co-op lab 2 hours' bus ride away.

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B.2: Gracias a Dios, Nicaragua (medium-small, certified organic and Fairtrade. Member of local co-op affiliated to PRODECOOP). Mr Eriberto Altamirano, Owner.

Has used Mirabiol brand, sometimes 2 applications near harvest period. Uses 3 packs per 0.7ha. Has to pay workers 25% more daily rate to spray late in the afternoon, after the end of the usual work day.

B.3: San Jose, Nicaragua (small/medium, certified Fairtrade) Francisca Gutierrez**,** Owner

Product used: Mirabiol rice with spores, from UCA Miraflor

Dose rate: equivalent to 886g rice per ha

Cost of product: Supplied on credit by SOPPEXCA to its co-op members

Cost per ha application: US$11.36 per ha [this is the same as cost of product retailed by UCA Miraflor]

Comparison with insecticides: compared with US$ 9.37-15.62 per 1 ha dose of endosulfan

General or hotspot application: in certain parts where CBB problems are highest, according to visual inspection to find early ripening and bored berries

Timing: June

Application considerations: Told by technicians not to apply any other product at the same time as fungus, or it might not work.

Effectiveness: Applied in June 2013 for first time, encouraged by SOPPEXCA co-op technicians and following their instructions. Too early to judge effectiveness. [*During grove visit, no Beauveria observed in a few trees checked]***.**

Views and perspectives:

- Doesn't consider price as costly

Discussion during interview re fact that we didn't observe any Beauveria 4-5 weeks after application in her grove: Considers that fungus might have been washed off by unusually rainy period since. She had also applied Amistar Xtra fungicide (azoxystrobin +cyproconazole) in early June before spraying Beauveria and used the same sprayer. Francisca and co-op technician Marlon both thought it was rain that might have reduced fungus effectiveness, rather than fungicide use or using same spray equipment.

B.4: Santo Domingo, El Salvador (small farm, organic certified, member of Jucuapense organic co-op). Mr Antonio Gómez, Owner.

Product used: 3B® spores on rice (PROCAFE)

Dose rate: 450g per 200 litre barrel. Use 1.42-2.13 barrels per ha

Cost of product: US$6.00-7.00 per 'pound' pack of 450g

Cost per ha application: US$9.23-13.84 per ha + 2.84 days labour

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Frequency: two applications per year

General or hotspot application: general

Timing: 1st in mid-June and 2nd in mid-July

Application considerations: No special measures taken to protect against sunlight. Adds molasses or raw sugar to tank mix [to help it stick]. Usually applies as soon as he obtains it from the co-op.

Effectiveness: Generally good. Thinks that 2nd application probably has now stopped broca infestation but not yet assessed whether this is correct. Hard to control totally and an application may be too late to kill some of the broca present if already entering the bean.

Views and perspectives:

- Doesn't know whether being organic and not using any chemicals helps or hinders broca levels. He usually spots some Beauveria growing one week or more after each application.
- Has applied Beauveria for 6 years but initially just scattered rice grains in groves, when pest pressure was low. More recently he sprays with knapsack sprayer.
- Takes 2.84 person/days to spray 1 ha.
- After washing spores off rice into solution, keeps rice grains in a cool place to encourage further sporulation

B.5: El Cerrito, El Salvador (small farm, certified organic, member of Jucuapense organic co-op). Ms Claudia Martinez and Mrs Maria Josefina Ruiz, Owners.

Confirmed they use Beauveria product from PROCAFE but no further details obtained

B.6:, Miramar, El Salvador (large farm, uncertified). Mr Alfonso Argueta, Farm Manager.

Views and perspectives:

- Has applied Beauveria and considers it does work but only when you already have considerable CBB infestation levels.
- Considers *Beauveria* a half-reasonable method but not an efficient control method to keep CBB levels low. In contrast, endosulfan will give you 100% control.
- Fungus will be killed by fungicides applied for rust disease

Comments from COEX exporter and grower, El Salvador. Mr René Fontan, Head of Agriculture Dept.

Since 2011 COEX have had to stop endosulfan use on their own farms and on certified estates whose coffee they export. Collaborating with PROCAFE, they've tried out cultural controls, traps and now *Beauveria* use and are able to get good CBB control.

- *Beauveria* biopesticide is the only spray product they now use since endosulfan prohibition in Rainforest and Utz- they don't want to use organophosphates like chlorpyrifos.
- On COEX estates, now apply one, maybe two, *Beauveria* sprays, after traps put up with the first rains.

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- Very short fungal viability of PROCAFE product once at ambient temperature is a major constraint to wider use. It's best to collect it with an ice box and apply the same day or store in a fridge but many farms don't have electricity. Many are several hours drive from a PROCAFE service centre so transporting fungus in heat can be problematic.
- Short shelf-life issue and failure to look after the product and apply it properly may explain why some farmers think it doesn't work.
- More farmers need to become convinced about Beauveria and try it out for themselves, with good advice and demonstrations. COEX supports this promotion work with PROCAFE.
- From 2014 COEX are setting up their own *Beauveria* production lab and plan promotion work with more of their certified supplier farms, including trials to look at cost effectiveness compared with other IPM methods and compatibility with conventional fungicide practices.

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Appendix C: Experience and advice from Beauveria producing organisations

Biopesticide production lab, Miraflor Union of Agricultural Co-operatives (UCA), Estelí, Nicaragua. Ms Fanny and Ms Mabel Garcia Lopez, Biopesticide Lab Managers.

The UCA Miraflor's Mirabiol lab has been producing *Beauveria bassiana* since 1998, with initial supervision and strains from the Nicaraguan National University.

Using Mirabiol Beauveria product

Product characteristics, storage and handling issues: Mirabiol® will control CBB, caterpillars in cabbage, capsicum, chilli and plantain weevil. Can also be used for cattle ticks, leafcutter ants. Mirabiol product's10 year national licence expired in 2011 and it's recently been renewed.

They will only sell good quality packs, with clean white and well-sporulated rice. Poor quality bags with more mycelial growth than spores are rejected, also any with yellowish, green or dark coloration indicating contamination by other fungi or bacteria. Farmers now know to reject any bags with yellowish colouring.

Lab had a period when well-sporulated *Beauveria* kept getting green fungal contamination after 4 days' growth. They won't sell bags with this contaminant as it can give users a bad cold-type allergy if contaminant spores are inhaled. This happened to Fanny in 2012 with one contaminated batch, when she opened bags to throw the product away and a cloud of the green spores came out and she suffered bad cold symptoms the next day. Under standard product use, however, farmers don't need to use any protective clothing when handling bags of clean rice with spores. *Beauveria* itself won't harm people, even if eaten.

Advice, training and customer satisfaction: They will explain to clients how to prepare the 'fungus &rice' product for spraying in the field. Re client satisfaction, UCA Miraflor did a customer evaluation some time ago and lab staff involved in asking farmers for feedback. Farmers expressed satisfaction because (a) product is cheap, (b) not harmful to environment and (c) doesn't affect human health. Most found it works well although some others not, maybe because they don't want to buy it anymore. One farmer complained that product didn't work but it's important to see how they applied it. Some farmers don't know how to use it in the field so lab staff offers practical training (paid) to go to their farms and show them how to prepare it and apply it.

Production and demand aspects: Production volumes always in response to advance orders received. In good years they've produced up to 2000 doses' worth. UCA Miraflor lab is not looking to get distributors to sell Mirabiol®. They tried this once with some commercial agrisupply stores who put a massive price mark-up on it. Now have an UCA staff member supporting publicity and marketing. SOPPEXCCA co-op near Jinotega are among UCA Miraflor's best customers.

No production in process during project visit in July 2013 but 100+ bags stored in fridge. In June 2013 SOPPEXCCA co-op in Jinotega ordered 60 doses. In 2012 they ordered over 1,000 doses but Mirabiol lab wasn't able to supply all that amount due to major contamination problems. Other labs producing *Beauveria* in Nicaragua's coffee regions are PRODECOOP lab in Palacaguina and one in Dipilto and possibly one still functioning in Matagalpa.

Recommendations how to convince more farmers to move towards more IPM methods: Best to work with farmer organisations or with private farmers, preferably via tailormade training sessions. Advise new clients to try out on 1-2 *manzanas* first [0.7-1.4ha] and see how they get on with it. Staff don't really like selling Mirabiol® to anybody without giving them a training session first.

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Biopesticide lab, PROCAFE research institute, Santa Tecla, El Salvador. Ms Karla Romero, Biopesticide Lab Manager.

PROCAFE collect several entomopathogenic fungi from field crops to build their collection of native strains of *Beauveria bassiana*, *Metarhizium*.

Using PROCAFE Beauveria product "3B"

Product characteristics, storage and handling issues: Sold in 'one pound' bags (450g) for US$5.00. One pound is dose for 1 *manzana* [0.7ha], diluted for application in barrel of 200 litres. Spore concentration guaranteed on label as 3.7 x 10^7 per ml. They store sealed retail bags in cold store at 8-10 ^oC, can be kept for up to 6 months but recommend to users a maximum storage time of 15 days at ambient temperature but best to apply straight away. Her advice is always that farmer should apply biopesticide as soon as possible and not store it.

Re PPE, she explained they do need to use masks and gloves, esp. in drying room, as staff can get affected by fungal spores liberated from rice. Fungus won't actually grow in human bodies at 37^oC but human antibodies can react defensively, with allergic reaction. Need to make sure masks are clean and you cover hair, hands and try to minimise exposure to spores. If you don't, you can rapidly get sinusitis, headaches, muscular pain. Over time you can get a covering of *Beauveria* over your eyeball if highly exposed. These health issues are not a problem for farmers using it, only for lab workers who are exposed regularly in closed atmosphere and without good protection and hygiene. She didn't have any allergy problems for years until this year.

Advice, training and customer satisfaction: Only complaints on non-effectiveness have been from clients who kept product for 2 months at room temperature! She insists on giving each client careful advice (how to use product, temperature of storage conditions) as many are sceptical or fearful at first about using a fungus in their fields. If they're doubtful, she may visit farm and apply 3B® herself in first instance, monitor and provide follow-up. Also takes opportunity to field collect more strains during farm visits.

Production and demand aspects: Confirms that demand for *Beauveria* products has been growing since lab first started 5 years ago. In first year they produced 15,000-20,000 pounds as it was paid for by donor and they gave it free to farmers. Produced 2,000 pounds in 2012. *Beauveria* produced to date in 2013 is 2,500 pounds. Lab produces according to demand. She reckons they'll produce more this year and already receiving more requests.

Both conventional and certified farmers are their clients for *Beauveria*. With the coffee rust attack in 2012, more people have been coming to ask for alternatives to control this disease and now getting interested in biopesticides for insect pests too. Coffee rust situation might end up bringing some benefits as more farmers get persuaded to use biopesticides.

Recommendations how to convince more farmers to move towards more IPM methods: Lots more talks, more activities to convince farmers that alternatives can work, via demonstration plots and more personalised technical advice, accompaniment. Just the 3B® product leaflet alone is not enough- it needs to be face-to-face as many farmers are very sceptical. Some will spray *Beauveria* and then because it doesn't seem to work, they'll then spray with endosulfan or another chemical, they don't wait long enough for biological products to carry out their function. *Beauveria* needs to be part of an IPM strategy with cultural, chemical & physical controls.

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Appendix D: Label information from *Beauveria* products used

Brocaril® manufactured by Laverlam International, USA

Container of 500g Brocaril WP

Labelled in Spanish with Colombian ICA registration number.

Active ingredient: *Beauveria bassiana* contains at least 2,000 million (2×10^9) viable conidia per gramme.

Inert ingredients: sterile microtalcum

Batch number and 12 month shelf life from date of formulation to expiry.

Carries Colombian blue label 'medium toxicity'

Brocaril WP contains a natural selective strain of the fungus Beauveria bassiana which affects CBB. Brocaril does not kill immediately but once the insect is in contact with treated foliage it will die over a period of 2-8 days.

Recommendations for use:

Brocaril WP can be used in conventional spray equipment. It is a microbial agent formulated for control of CBB.

Dose: For CBB in coffee apply at 50-100g per ha

Period: apply when CBB levels between 2-5%

Preparing the mixture:

Add Brocaril to a bucket containing 2 litres water and stir vigorously until completely dissolved.

Pour solution into total spray volume and mix vigorously

Apply 150-200 litres per hectare of mixture for terrestrial spraying.

Recommend adjuvants to be added to regulate pH and hardness.

Consult a technical advisor.

MicosPlag® WP manufactured by Orius, Colombia.

Biological agent, bioinsecticide bioregulator of insect pests.

Container of 100g wettable powder

Labelled in Spanish with Colombian ICA registration number.

Guaranteed composition:

Paecilomyces lilacinus 100 million spores per gram

Metarhizium anisopliae 50,000 spores per gram

Beauveria bassiana 50,000 spores per gram

Added ingredients c.s.p: 100g

Batch number and 12 month shelf life from date of formulation to expiry.

Carries Colombian blue label 'medium toxicity'

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Recommended for CBB

Dose; 100-300 g per ha

Apply in IPM before flowering and at grain filling.

NB web advert sheet for MicosPlag recommends 100-150g per ha in 200 litres water when CBB levels between 1-3%. When CBB levels > 5% apply in mixture with a chemical insecticide (1.5-2 litres) and complement with ReRe. Technical sheet recommends 100-150g/ha in foliar spray at preflowering and at pasty bean stage.

This product sold for wide range of insect pests and nematodes in plantain, flowers, vines, tomato, etc.

Mirabiol® product manufactured by UCA Miraflor co-operative, Nicaragua

Composition: Beauveria bassiana 3.5 x 10^{11} conidia

Inert ingredients: rice

Net content: 310 grams

Production and Expiry dates

Artesanal product made and distributed by UCA Miraflor, Estelí, Nicaragua.

Tel 2713-2971 email: miraflor@cablenet.com.ni

[Works out at US$11.40 per 1 ha dose of 886g rice with spores]

Info on Mirabiol leaflet (supported by FUNICA national foundation for Agricultural Technology Development and Swiss Cooperation in Central America)

Mirabiol is a harmless product to man and animals, without preservatives or chemical additives, does not induce insect resistance nor contaminate water sources. It is mainly used for coffee berry borer and cabbage caterpillar control.

Preparing the solution

- Add content of one bag to 3 litres water and wash by hand to separate the fungus from the rice.
- Sieve to obtain the liquid solution.
- Rice particles remaining in the sieve can be scattered in the crop field.
- Divide the suspension obtained into the number of tankfuls of water to be used in 0.5 manzana [0.35ha]

Recommendations

- ✓ Carry out 2 applications in coffee and 3 in cabbage during the season
- ✓ Once product is mixed with water apply immediately during cloudy days or after 4pm in the afternoon.

Leaflet includes diagram showing how the fungus survives in the coffee grove:

"3B" ® product manufactured by PROCAFE, El Salvador

Microbial insecticide based on *Beauveria bassiana* for control of coffee berry borer

For sale via PROCAFE HQ and 3 regional offices.

Precautions & Instructions for Use

Avoid inhaling powder released when preparing tank mix. Careful handling of any product is a good safety measure. Use mask, gloves and appropriate clothing during application.

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Environmental Protection: Does not contaminate the environment, has no harmful effects for plants, animals or humans. Does not encourage development of secondary pests.

Handling & Storage: Do not transport with or store next to foodstuffs, pesticides or clothing. Keep refrigerated or in a cool place away from direct sunlight for up to 2 weeks.

READ LABEL BEFORE USING PRODUCT

Beauveria bassiana: contains 450 g rice with spores for an approximate concentration of 3.7×10^7 spores/ml

Biological product for control of CBB *Hypothenemus hampei*, developed using native strain of *B. bassiana* isolated from CBB and reproduced on rice. Acts as a microbiological agent on contact. On contacting the insect, the fungal spores germinate and start to degrade the cuticle, penetrating the body, producing enzymes and toxins. These mechanical effects cause the insect to stop moving and later die.

Preparation & Application Method: Can be applied in two methods:

a) Place contents of bag on fine mesh and immediately plunge into barrel of 200 litres of water, submerging it several times to release the spores
b) Place bag contents into bucket of water and shake strongly to separate spores. Then filter water containing spores through a fine strainer and put strained liquid into barrel of 200 litres of water. Remaining rice grains can be sprinkled directly in the coffee plot, or kept in a cool place to encourage more spore production

Prepare the tank mix under shade and apply preferably in the morning or late afternoon using a knapsack sprayer directed straight onto berries. Once preparation is ready, apply the same day. Avoid spraying during intense sunlight.

Always calibrate spray equipment and make sure they are clean and free from any chemical residues. Do not use equipment used to apply fungicides. Not compatible with fungicides, insecticides, herbicides or foliar fertilisers.

[Dose for 1 ha would be 639g, at cost of US$7.10 as sold by PROCAFE].

PROCAFE 2 page technical note leaflet on ***Beauveria bassiana fungus: a tool for biological control of CBB***

Briefly describes what Beauveria is; how it works against CBB; application period; under what coffee grove conditions; how to carry out CBB incidence sampling, using 5% bored berries as action threshold to avoid economic loss; how to prepare and apply Bb product; advantages of using Bb

Recommends Bb to be applied June-August in El Salvador during berry development stage, 90-120 days after main flowering period. Apply in the morning and direct spray onto berries.

Explains that Bb can only attack CBB when pest is outside the berry or just beginning to penetrate the flesh.

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Appendix E: Responses to on-line survey questions on biopesticides

Table E1. Survey respondents' views of effectiveness of Beauveria biopesticide as a control method

Country/Case	Effectiveness
Indonesia (a)	One private coffee plantation regularly use this product in Banyuwangi, Indonesia. Best methods for CBB control: Using attractant and Beauveria.
Indonesia (b)	Ranked 7th of 7 recommended IPM methods
Indonesia (c)	Reasonably Effective. Using Beauveria bassiana 40-60 % can control CBB pest.
Indonesia: (d)	*mentions using Beauveria but no details*
India	Gives application rate only
Mexico (a)	Not very effective. Must be applied at precise moment when CBB penetrating berry.
Mexico (b)	Not very effective. Supplied by Xicotepec district Plant Protection office. We don't use now since we found one year that fungus was not controlling CBB because spore dose too low.
Brazil (a)	Not effective, because in unshaded coffee, light destroys Beauveria.
Brazil (b)	Neither *Beauveria* nor *Metarhizium anisopliae* works under Brazilian conditions
Peru (a)	Reasonably Effective
Peru (b)	Highly Effective
Colombia (a)	Highly Effective. With improvements in Beauveria strain & production methods, can cause up to 67% mortality of dispersing females if applied at correct time. Applied to infested berries on the ground, can prevent emergence of 50% of CBB from these berries and kill up to 75% of adults arriving on [new?] berries. Surviving CBB lay 90% fewer eggs. See published papers for details.
Colombia (b)	Reasonably Effective. As long as CBB is in position a or b in berry flesh (according to CENICAFE methodology).
Colombia (c)	Reasonably Effective. As long as combined with regular berry removal, monitoring of flowering periods and CBB position in berries.
Colombia (d)	Reasonably Effective. Not used much but a very good method. More useful than parasitic wasps, but product needs to be produced in effective formulation to enable easy dosing and conservation [i.e. longer effective action in the field?]
Colombia (e)	Highly Effective. Much work to introduce fungus, now easily found [means can be bought easily or persists in coffee grove?]
Unspecified Latin American (a)	Depends on application timing and quality of product & application method.
Unspecified Latin American (b)	Highly Effective

Colours refer to ranking of Not Very Effective (red); Reasonably Effective (yellow); and Highly Effective (green).

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Table E2. Beauveria application methods described by respondents

Country/Case	Method details
India:	For 200 lit barrel- 10million conidia/ml- 1 kg of rice cultur+100ml of APSA 80 mix.
Indonesia (c)	Farmers develop *Beauveria bassiana* from infected CBB. Application (1) spraying the fruit to the ground & (2) seed soaking affected CBB with water Beauveria and spread on land. Apply 5 times during Mar-Jul.
Peru (a)	2 sprays: (i) end Nov. using 4 bags of product, and (ii) in Jan. using 2 bags.
Peru (b)	Spray using 1 kg product/ha. 2 applications at bean filling and 'creamy' soft stages. Spray in late afternoon. Recommend also spraying before 'creamy' stage.
Colombia (a)	Between 1-5 sprays/year, depending on economic thresholds developed for Colombia. Recommended to coffee farmers as part of FNC IPM strategy.
Colombia (b)	Originally applied Beauveria from artisanal production, now only commercial products. 1-2 sprays/ year 90-120 days after major flowerings and only if >5% CBB levels, starting to penetrate berries.
Colombia (c)	Using knapsack sprayer, up to 200 g [per ha?], when CBB level >2%.
Unspecified Latin American (b)	One foliar spray.

Table E3. Beauveria application cost estimates given

Country/Case	Cost estimate
Indonesia (c)	Very cheap: 1-2 US$
Peru (a)	~5US$ per 800g
Peru (b)	17US$ for product. Labour ~19US$. Total cost ~ 36US$
Colombia (a)	Depends on product purchased, between US$16-36
Colombia (b)	10 US$ per 100g pack
Colombia (c)	10 US$
Colombia (e)	Moderate price of commercial products

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