Control of coffee berry borer and increase of coffee yields using Surround WP (kaolin)

Final Report for OW11-308

Project Type: Professional + Producer
Funds awarded in 2011: $47,648.00
Projected End Date: 12/31/2014
Region: Western
State: Hawaii
Principal Investigator:

Dr. Shawn Steiman
Coffea Consulting

Project Information

Abstract:

In two seasons while fruits were on trees, Surround® WP, a kaolin-based particle film, was applied to coffee (*Coffea arabica*) biweekly to measure its efficacy in controlling the coffee berry borer (CBB, *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae: Scolytinae)) and increasing coffee cherry yields. Surround® WP decreased CBB infestation 28-79% with adequate coverage. On one farm, Surround® WP increased coffee cherry yields by 15%.

Introduction

One of the most destructive pests of coffee (*Coffea arabica*) is the Coffee Berry Borer, (CBB) *Hypothenemus hampei* Ferrari (Coleoptera: Curculionidae: Scolytinae). The females, 1.5 – 2.0 mm in length, bore through the apex of immature and mature fruit and into the developing coffee seed, the marketable product. Once inside the seed, the females lay their eggs. Inside the seeds, the eggs hatch and grow into mature adults. Upon fertilization from their brothers, the now-pregnant females leave the seed to find a new one to lay their own eggs. As most of the life cycle of the beetle is spent buried within a fruit and seed, it is very difficult to control. The best control method is to limit the potential population of the beetle with field sanitation; that is, by removing every cherry possible at the end of each season. This is an expensive, laborious, and often difficult task; thus, it is typically supplemented by other control methods. Traps with lures are recommended to monitor the presence and intensity of the population within a particular segment of the field. When high populations are discovered, formulations of the entomopathogenic fungus *Beauveria bassiana* can be sprayed to attack the beetle. Finally, some synthetic agrochemicals, such as Endosulfan, are effective in controlling the CBB.

Coffee is one of the most important agricultural crops in Hawaii. In 2011, it was the

sixth highest earning commodity in the state, earning the state approximately $31.5 million annually. With 830 total farms, there were more coffee farms than any other type of farm, about half of which were located in Kona (Hawaii Annual Statistics Bulletin 2011).

In 2010, the CBB was confirmed to be present in Kona, Hawaii (Burbano et al. 2011). Since that time, yield reductions have been estimated at an average of 20% across the region (Hicks 2013). Controlling the CBB has proved particularly challenging in Kona. As labor is very expensive and many farms are located on porous lava rock, it is very difficult to maintain excellent field sanitation practices. In addition, the effectiveness of *Beauveria bassiana* formulations has been reported to control 20% of the CBB population, even in the humid areas of Kona where it is most likely to be effective (Bittenbender 2013). Finally, effective synthetic agrochemicals, such as Endosulfan, are banned in the U.S. and are not available as control methods. Consequently, alternate control methods were sought.

Particle film technologies have proven to be effective in controlling a variety of insect pests (Glenn and Puterka 2005). Particle films can act against insects in a number of ways. These include mechanical abrasion, desiccation, disruption of visual and tactile perception, interruption of feeding, and interruption of oviposition.

Surround® WP, a kaolin based particle film technology, has proven effective against a range of insect pests, including other Curculionidae (Joubert et al. 2004, Thomas et al. 2004, Lapointe et al. 2006). It is relatively low in price, organic-approved, and easy to apply. Its use does not influence coffee cup quality and, when used consistently for two years, it can increase coffee yields (Steiman et al. 2007, 2011).

This research tested the efficacy of Surround® WP in controlling the CBB and increasing yields in coffee.

Project Objectives:

The objectives of this project were to 1) measure the effectiveness of Surround WP as a control measure for the coffee berry borer, 2) test, on working farms, if Surround WP can increase coffee yields, and 3) share the information with as many coffee farmers in Hawaii as possible.

Cooperators

- Robert Barnes

  robert@konarainforest.com

  Farmer

  Kona Rainforest

  PO Box 340
  Captain Cook, HI 96704

  (808) 328-1941 (office)

- Dr. Elsie Burbano

  eburbano@hawaii.edu

Co-PI

3050 Maile Way
Gilmore Hall #310
Honolulu, HI 96822

(808) 754-8328 (office)

- Bob Foerster

  coffee@pendragonhawaii.com

  Farmer

  84-4987 Mamalahoa Hwy
  Captain Cook, HI 96704

  (808) 328-7345 (office)

- Ron Lake

  konalisa@yahoo.com

  Farmer

  83-5475 Painted Church Road
  Captain Cook, HI 96704

  (808) 328-9941 (office)

- Bob Nelson

  bob@lehuulafarms.com

  Farmer

  Lehuula Farms

  79-7350 Mamalahoa Hwy
  Kealakekua, HI 96750

  (808) 322-2902 (office)

- Deb Sims

  deb@sweetspiritfarms.com

  Farmer

  P.O. Box 832
  Honaunau, HI 96726

  (808) 328-7442 (office)

Research

Materials and methods:

Study location

In 2011, experiments were established on four active coffee farms in Kona, Hawaii. All farms were growing *Coffea arabica* 'Kona Typica' at elevations ranging from 250 – 600 meters asl. Farmers were instructed to maintain their typical pruning and fertilizing regime. No trees were selected that would be due for a major pruning event during the experiment. See Table 1 for farm elevations and fertilizing practices.

Experimental design

Experimental units consisted of eight consecutive coffee trees in a row with the outer two trees being border trees. Data were not collected on the border trees. Three of the farms were designed as completely randomized blocks (CRBD), with the blocks determined by their location on the farm. Due to the planting design of the remaining farm, it was set up as a completely randomized design (CRD). Experimental units, whether blocked or replicated, were done so in triplicate. Three farms had only two treatments and, because of its larger labor force, one farm had four treatments. See Table 1 for each farm's experimental design and treatment layout. The four possible treatments were Control, Surround® WP, Mycotrol® O, and Surround® WP + Mycotrol® O. The Control treatment had no spraying of any product. The Surround® WP treatment had fortnightly sprayings of 5% w/w Surround® WP (NovaSource, Phoenix, AZ, USA, http://www.novasource.com) with .3% w/w NuFilm® P sticker (Miller Chemical and Fertilizer Corporation, Hanover, PA, USA, http://www.millerchemical.com). The Mycotrol® O treatment had monthly sprayings of .06% Mycotrol® O (Bioworks, Victor, PA, USA, http://www.bioworksinc.com), an insecticide composed of *Beauveria bassiana*, with .03% Green Cypress EcoSpreader (Monterey AgResources, Fresno, CA, USA, http://www.montereyagresources.com). The Surround® WP + Mycotrol® O treatment had both products sprayed as described above; however, they were not sprayed simultaneously but offset by a week. Farms used either a backpack sprayer or tractor-mounted mechanical sprayer; see Table 1 for type used on each farm. Spraying commenced six weeks after flowering and continued until the completion of the harvest for two years (2011 and 2012). No additional pesticides were sprayed on any farm.

Data collection

CBB infestations. Coffee berry borer infestation and yield data were collected in three to four week intervals beginning at the start of the harvest season (September) and continuing until all the cherries were removed from the trees (January). To calculate CBB infestation, four branches were randomly selected from each experimental unit (twi branches on each side of the row) and all the coffee cherries (underripe and ripe) were counted on the branch. The cherries with CBB holes were counted and that value was divided by the total number of cherries on the branch to produce a percentage of infestation.

Coffee yields. After the CBB counting, all ripe and nearly ripe cherries were harvested from all the trees in the experimental unit and weighed. At the end of the harvest season, the individual harvest weights were summed to generate a total yield for the experimental unit.

Statistical analysis

All CBB counts from a single replicate of an experimental unit were considered replicates within a harvest season. Thus, if an experimental unit were visited seven

times a season and each visit generated four counts, then that experimental unit would have 28 data points in the analysis. The percentage of CBB infestation and cherry yields were analyzed as a CRD or CRBD as appropriate using Tukey's multiple comparison test when significant differences were found at $p \leq 0.05$. Statistical analysis was performed using JMP 9.0 statistical software (SAS Institute, Inc., Cary, NC, USA, http://www.sas.com).

Research results and discussion:

Effect of Surround® WP on CBB infestations

In 2011, only farms 2 and 4 sprayed the Surround® WP biweekly and maintained good coverage of the plants. Farms 1 and 3 did not follow the spraying schedule and, consequently, left the berries poorly covered. Therefore, only farms 2 and 4 showed significantly fewer infested berries on plants sprayed with Surround than on control plants ($F = 16.51$, $df = 1,2$, $P < 0.0001$) ($F = 7.61$, $df = 3,4$, $P < .0001$), respectively (Figure 1). Farm 4, which had the additional treatments, showed no significant differences between the Mycotrol® O and untreated plots. Similarly, there were no significant differences between the Surround® WP and Mycotrol® O + Surround® WP treatments.

In 2012, all the farms adjusted their spray methods and sprayed according to the schedule. This resulted in better overall coverage on all the farms. In 2012, the number of infested berries was significantly reduced on plants sprayed with Surround® WP compared to control plants (Farm 1: $F = 6.26$, $df = 1,2$, $P = .0142$; Farm 2: $F = 3.76$, $df = 1,2$, $P = .0269$; Farm 3: $F = 10.05$, $df = 1,2$, $P < .0001$; Farm 4: $F = 10.47$, $df = 3.4$, $P < .0001$) (Figure 2). On farm 4, there were no significant differences between Surround® WP and Surround® WP + Mycotrol® O treatments. However, there were significantly fewer infested berries between the control and Mycotrol® O treatments and between the control and Surround® WP + Mycotrol® O treatments.

No block effects were found on any farm.

Effect of Surround® WP on coffee yield

In 2011, coffee berries on farm 3 were harvested during regular farm practices in the experimental plots; therefore, yield estimates were compromised. Farms 1 and 2 did not show significant differences in yield. Farm 4, however, did show significant yield differences ($F = 6.31$, $df = 3,4$, $P = .0276$. In 2012, farm 3's plots suffered from overbearing-dieback; therefore, yield estimates were compromised. Only farm 2 showed significant yield differences in 2012 (Table 2) ($F = 25.58$, $df = 1,2$, $P = .0369$).

No block effects were found on any farm.

Discussion

This study reports the first attempt to reduce the attack of the CBB on coffee berries using kaolin particle film. Plots treated with kaolin biweekly showed significantly less infested berries than untreated plots. The levels of infestations were reduced to 28% and 79% in 2011 and 2012, respectively. This suggests that kaolin particles might have caused a barrier effect to protect the berries from the CBB attack. Moreover, in

both years, only the farms presented uniform kaolin coverage had significantly fewer infested berries. This underscores the importance of continuous and uniform coverage of kaolin to maintain its effectiveness.

Larentzaki et al. (2008) reported that *Thrips tabaci* feeding marks were observed in areas with thin Surround® WP deposits, suggesting that the uniformity of particle film coverage is essential. In this study, less CBB attack was observed when Surround® WP particles covered the blossom area of the berries completely which is the site where females prefer to enter the fruit. Therefore, a complete and uniform coverage on plant surface is essential for kaolin particle to be effective (Glenn et al. 1999).

The combination of Surround® WP and Mycotrol® O reduced the infestations levels by 87% and 94% in 2011 and 2012, respectively; somewhat more than the Surround® WP alone. However, as there was no significant difference between this treatment and Surround® WP, it is not clear if there was a synergistic effect between Surround® WP and Mycotrol® O or simply that the CBB was repelled by the presence of Surround® WP as was shown in the Surround® WP treatment alone.

Several studies have reported the use of kaolin as a physical barrier that would conceivably repel arthropods or suppress infestations by making the plant visually or tactually unrecognizable as a host (Glenn et al. 1999). Additionally, feeding, insect movement and other physical activities can be severely disrupted by the attachment of particles to the insect's body.

Feeding by the root weevil *Diaprepes abbreviates* (L.) adults, a pest of citrus and ornamental plants, was reduced by 68-84% on foliage treated with Surround® WP compared with adults fed untreated foliage (Lapointe 2000). Kaolin particles were also reported to reduce significantly female longevity, mating success, feeding and number of eggs of the silverleaf whitefly (*Bemisia argentifolii* Bellows & Perring (Homoptera: Aleyrodidae)), *Thrips tabaci* (Thysanoptera: Thripidae), the obliquebanded leafroller (*Choristoneura rosaceana* (Harris)) and the codling moth (*Cydia pomonella* (L.) (Lepidoptera: Tortricidae)) (Knight et al. 2000, Unruh et al. 2000, Lianng and Liu 2002, Larentzaki et al. 2008).

Additionally, the whiteness and brightness qualities provided to foliage treated with kaolin have been reported as the primary factor for reducing colonization and infestation of the root weevil *Diaprepes abbreviates* (L.), *Thrips tabaci* (Thysanoptera: Thripidae) (Cottrell et al. 2002, Showler 2002, Larentzaki et al. 2008).

This study showed that the CBB is less inclined to attack berries that are coated with Surround® WP particles which suggests that CBB preference can be attributed to visual cues or the abrasion of the kaolin particles during CBB boring attempt. Other hypotheses for Surround® WP's mode of action include the disruption of possible plant volatile attractants or the CBB's gustatory dislike of the particles, though no known data support nor refute these ideas.

Good coverage is essential to protect the berries from the CBB attack, and therefore, multiple applications may be required. Our results suggest that Surround® WP has potential to be used as a barrier on coffee berries to reduce CBB attack. It

may be used as an alternative tool in an integrated management against CBB and offer an alternative management for organic coffee growers as well, as long as applications are made appropriately.

Although an economic analysis was not conducted, the cost of materials of the current standard CBB control method in Kona, *Beauveria bassiana*, sprayed monthly, and the cost of Surround® WP, sprayed biweekly, are similar. Thus, it appears that biweekly applications of Surround® WP would be economically feasible relative to current costs of control.

The coffee yields were not influenced much by the application of Surround® WP. Discounting the yield results from farm 3 (accidental harvesting in 2011 and overbearing-dieback in 2012) and the 2011 results from farm 1 (inadequate spraying), only one statistically significant yield difference was observed amongst the three other farms in both years. However, numerically, the yields seem to trend in an increasing fashion with use of Surround® WP. This is similar to the results from Steiman et al. (2011), where there was a significant difference in only one year for Surround® WP use and no differences with most other shade treatments. The use of six-tree experimental units in this study was chosen to decrease the yield variation between plots presumed to confuse past results. Unfortunately, the results presented here do not permit a determination on the effect of Surround® WP on coffee yield, only more confusion.

Surround® WP works as a repellent and shown to be effective when applications were continuous and uniform. Therefore, it must be applied before CBB infestation begins rather than when a severe infestation is reached. In Kona, CBB has been observed attacking small berries (aged 60 days from flowering; Greco pers. observations) and levels of infestation increase with fruit development and ripening (Bustillo et al. 1998). Due to the climate conditions and coffee phenology, multiple applications of kaolin are be necessary. Surround® WP works as a repellent and it has been shown to lose effectiveness when untreated host plants are unavailable (Showler 2002); therefore, leaving some unsprayed coffee trees could work as trap trees and attract the beetles present on the fallen and unharvested berries from the previous season. Future studies on Surround® WP as a protective measure against CBB should be conducted to explore the optimal duration of coverage, the optimal frequency of spraying, the lowest possible concentration of solution required, and its integration into IPM programs with.

- Data figures

Participation Summary

Educational & Outreach Activities

PARTICIPATION SUMMARY:

Education/outreach description:

Several manuscripts were submitted to academic journals for publication. All were rejected.

A short summary sheet was produced for easy distribution to farmers. The University of Hawaii includes this summary sheet in their materials for farmers.

Project Outcomes

Project outcomes:

After a few workshops, several farmers expressed interest in using Surround WP to control CBB. After a season of use, those farmers expressed a positive sentiment about the product; they believed it was helping control the pest.

Based on this data, the University of Hawaii promotes Surround WP as a method for controlling the coffee berry borer.

Economic Analysis

n/a

Farmer Adoption

After a few workshops, several farmers expressed interest in using Surround WP to control CBB. After a season of use, those farmers expressed a positive sentiment about the product; they believed it was helping control the pest.

Sustainable Agriculture Research & Education US Department of Agriculture

This site is maintained by SARE Outreach for the SARE program and is based upon work supported by the National Institute of Food and Agriculture, U.S. Department of Agriculture, under award No. 2019-38640-29881. SARE Outreach operates under cooperative agreements with the University of Maryland to develop and disseminate information about sustainable agriculture. USDA is an equal opportunity provider and employer.