Push-pull management of the Black Coffee Twig Borer (Xylosandrus Compactus) in Smallholder Coffee Farms in Uganda

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Foreword

Welcome to the journey of exploring the coffee pest management methods in Uganda. Before we start, I would like to briefly talk about the journey of my own study at master's program Agroecology at the Swedish University of Agricultural Sciences (SLU).

After getting my bachelor's degree at the Sichuan Agricultural University in my home country China, I worked in agricultural industry for a few years. Then, I moved to Sweden with my family. Here, I noticed that people have a very good awareness of protecting the environment, and the whole society values sustainability very much. This triggered my interest in the relationship between agricultural activity and natural environment, and I stated to search for relevant master's programs, which eventually led me to this Agroecology program at SLU.

The courses I took during my master's study really deepened my knowledge of a healthy agricultural system. Fortunately, I got the opportunity to conduct my thesis research in Uganda with the support from supervisor Teun Dekker. Beyond basic knowledge and theories I learned from courses, this journey lifted my understanding of scientific and practical experimental design. Aside from getting to experience a completely new culture, I also learned a lot about how the smallholder farming system works.

Agroecology, to me, is about finding practical, interconnected solutions to the many challenges facing our food systems today. It teaches me how to solve a complex problem utilizing different tools. It gives me hope that a sustainable future is possible. Now, I am excited and let us dive into my research journey.

Abstract

The coffee industry in Uganda plays a critical role contributing to its export earnings. However, it is severely affected by a biotic stressor, the Black Coffee Twig Borer (BCTB), causing unstable income due to BCTB-infested yield loss in smallholder farms. The Ugandan smallholder coffee farmers face challenges to control the BCTB due to some knowledge gaps such as limited understanding of BCTB biological behavior and environmental triggers of infestations. The field trial employed a push-pull management strategy, i.e a combination of repellents and attractants in search of a sustainable solution. This was combined with a semi-structured interview and an online survey to draw a full picture of the situation. In eight plots in Kamuli district of Uganda, two repellent treatments i.e. verbenone (T1) and synergy of verbenone and methyl salicylate (T2) were applied in a slow release device and infestation was monitored. Both treatments decreased the total number of infested twigs and total number of new entry holes at early stages, with T2 showing a more profound effect. T1 and T2 also lowered the number of borers captured by attractant traps as compared to control. However, the effectiveness of both repellents decreased over time. Interestingly, a significant positive relationship was found between shade level and infestation rate under control and T1, also confirmed farmers' answer in the survey and interview, stating that a higher shade level might contribute to a more severe BCTB infestation. No correlation was, however, found under T2, which may indicate that repellency of BCTB may disrupt the otherwise clear effect of shade on infestation levels. Farmers commonly practiced intercropping in their coffee farms for varying purposes. However, they lacked the knowledge of selecting the best intercrops to avoid elevating the BCTB infestation rate. Additionally, the interview showed good awareness of farmers of the BCTB problem, but poor ability to identify and cope with it. Removing infested material such as twigs and plants and burning them are known to be an effective way to control BCTC infestation level, but it is hard for coffee farmers to manage to do it due to labor intensive work. The interview also identified a large gap of perception between farmers and extension officers about the accessibility and quality of the services. This results that extensions services are nor fully capable of serving the needs of the farmers, and that communication can be improved. This thesis work aims to examine the effectiveness of the two types of repellents on mitigating BCTB infestation based on data acquired from local Ugandan-farm-grown coffee trees. This work was also designed to update the local people's perception on BCTB management. The research can be further deepened to more detailed research on the mechanisms behind the repellents. The information extracted from the interview depicts the unstable coffee cultivation system in Uganda, highlighting the need for a more effective extension service system in the future.

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Abbreviations

BCTB	Black Coffee Twig Borer
UBOS	Uganda Bureau of Statistics
AFDB	African Development Bank Group
UNHS	Uganda National Household Survey
UCDA	Uganda Coffee Development Authority
ICO	International Coffee Organization
COI	Coffee Quality Institute
MAAIF	Ministry of Agriculture, Animal Industry and Fisheries
NSDS	National Service Delivery Survey
ASSP	Agriculture Sector Strategic Plan
SPLAT	Specialized Pheromone and Lure Application Technology

1. Introduction

1.1. Uganda Agriculture

Agriculture contributes to 24% of the total GDP in Uganda (AFDB, 2024). It supports economic growth, reduces rural poverty, provides employment, ensures food security, and contributes significantly to export earnings (AFDB, 2024). Approximately 80% of the households are involved in agricultural activities. Compared to urban areas (47%), rural areas have almost two times as many households (90%) working in agriculture (UBOS, 2016). According to the Uganda Household Survey (UNHS) 2019/2020, approximately 68% of Ugandans are involved in agriculture, agroforestry and fishing (UBOS, 2021).

However, the high dependence of the local economy on agriculture results in rural poverty. Particularly, the income of 53% of Ugandan households heavily relies on subsistence agriculture (UBOS, 2021). Thus, improving agriculture and increasing agricultural productivity can help reduce the economic gap between urban and rural regions. Uganda is also regarded as a food basket in the East African region. Thus, enhancing agricultural production in certain regions is

crucial for reducing rural poverty, ensuring food security and achieving the Sustainable Development Goal of Zero Hunger (MAAIF, 2016; WFP, 2018).

Smallholder farmers constitute a significant portion of the agricultural sector in Uganda. More than half (54%) households involved in agricultural activity are smallholder farms (UBOS, 2020). Additionally, the FAO also highlights that family farms in Uganda are predominantly smallholders, which account for a large portion of the country's agricultural landscape (FAO, 2018). However, smallholder farmers struggle with high input costs (seeds, fertilizers, pesticides), poor infrastructure, and expensive or inadequate post-harvest storage. They also operate in a largely informal, cash-based economy with limited access to credit, savings, markets or payment options. The local farming activities also heavily rely on middle men who have limited levels of education (Anderson et al., 2016). Therefore, applying relevant improvements, such as increasing productivity and facilitating border market access, benefits both the smallholder farmers' livelihood and the country's overall agricultural output.

1.2. Coffee production in Uganda

Coffee is a crucial commercial crop that contributes to a large extent to the economy in Uganda. It contributes to approximately 15% of the total export earnings in the last ten years (ICO, 2019). Coffee export performance amounted to 6.1 million bags that was worth US$ 559 million during 2020/21. Of this total, 5.3 million bags were robusta coffee (87%), while Arabica coffee accounted for 0.7 million bags (12%) (UCDA, 2022b, 2022a). In addition to generating revenue, it provides employment for around 2.5 million people, who mainly depend their livelihood on coffee cultivation and trade (ICO, 2018). There are over 1.7 million coffee growers in Uganda, and 85% of them are categorized as smallholder farmers whose coffee garden is less than 0.25 hectares (ICO, 2018).

Uganda is the 8th largest coffee producer worldwide, and the 2rd largest coffee producer (including robusta and arabica) in Africa after Ethiopia in 2019/2020 (ICO, 2021). Out of 144,150 km^2 of agricultural land in Uganda, 5,830 km^2 is used to grow coffee (UCDA, 2022b; WorldBank, 2021). Ugandan coffee has been graded as the 3rd best tasting coffee by professional tasters certified by the Coffee Quality Institute (CQI) (Beanpoet, 2020).

In Uganda, there are two main coffee species, i.e., robusta coffee (*Coffea Canephora*) and arabica coffee (*Coffea Arabica*). Robusta coffee is native species and naturally grown in the forest along lake Victoria crescent (ICO, 2018). Uganda ranks the 4th largest robusta coffee producers in the world (ICO, 2019), and it contributes to 80% of the total coffee exportation earning (UCDA, 2022a). Due to its high resilience to warmer temperature and pest/disease, robusta is typically grown in altitudes of 1200-1500 m above the sea level throughout the country, such as central, eastern, mid-north, west Nile and western Uganda (ICO, 2019), which makes Uganda robusta the world's finest robusta coffees.

Another species of coffee is arabica coffee, which is originally from Ethiopia. In 1912, arabica coffee was first introduced to the Mount Elgon region from Bugisu. The high altitude of the Mount Elgon region (2300 m above the sea level) gives the local coffee high quality. Compared to robusta, arabica requires cool temperature and high moisture so that it mainly grows in highland altitudes over 1500 m, such as Mount Elgon mountain in eastern mountain range bordering Kenya, the western Nile region, and Mount Rwenzori in the west bordered with Congo (ICO, 2019).

Due to the high resistance to heat, performance on low fertility soil and pest/disease, robusta coffee has around 30% higher yield than arabica coffee (UCDA, 2022b). However, the average export price of robusta is about 30% lower than arabica during the last ten years (UCDA, 2022a) due to its lower acidity, bitter, woody and less fruity taste compared to arabica coffee.

1.3. Black coffee twig borer (BCTB) threat for coffee production in Uganda

The Black Coffee Twig Borer (BCTB), also known as *X, compactus* (Eichhoff) (*Coleoptera: Curculionidae: Scolytinae*), is one of the damaging pests to coffee plantations.BCTB is a wood-boring insect that is originally from Southeast Asia and has spread across coffee-growing regions worldwide (Wood, 1982). Female BCTB responsibly bore tunnels inside the coffee branches and built a gallery where they lay eggs, which cause damage to plants (Hara & Beardsley, 1979). These galleries and tunnels disrupt the plant's water-conducting vessel system (xylem), leading to reduced nutrients and water flow, which causes wilting and yellow or blackening bark/twigs of plants (**Figure 2**) and further weakens or even kill the infested plants

(Masuya, 2007; Ngoan et al., 1976). The BCTB is an ambrosia beetle that lives in symbiotic association with ambrosia fungus produced by the female beetle, which the larvae typically feed on (Hara & Beardsley, 1979). The invasion of the ambrosia fungus into branches leads to necrosis in the bark and desiccation in the xylem, which then spreads further into the plant to stop the flow of water and nutrients (Greco & Wright, 2012).

Adult male BCTB are flightless, spending their entire lifecycle inside the host tree, while the winged adult females, capable of flying over 100 meters, initiate new attacks, causing most new infestations. It reproduces via haplodiploidy. In this process, haploid males are developed from unfertilized eggs, while diploid females are developed from fertilized eggs (Greco & Wright, 2012).

Figure 1. Images of BCTB in Uganda (left is male BCTB, right is female BCTB)

Figure 2. Symptoms of BCTB infestation on coffee plants (Left - blackening twig, right - wilting leaves and blackening twig). Photo by Sushu Yang.

In Uganda, BCTB has rapidly become a serious problem for coffee cultivation across the country since it was first reported in 1993 in Bundibugyo district (Egonyu et al., 2009). According to a qualitative survey including 26 districts across Uganda (Kagezi, et al., 2013), 8.6% of coffee twigs were infested by BCTB, which translated to about 8.6% of coffee yield losses. BCTBs rapid expansion has imposed a great threat to local coffee productivity. Thus, strategies to suppress its occurrence in particular coffee are urgently needed. Apart from that, the BCTB is a polyphagous pest, infesting over 224 plant species, including mango tree, eucalyptus trees, avocado tree, *Albizia Chinensis*, *Ficus Natalensis* and *Maesopsis Eminii* (Kagezi, et al., 2013). Moreover full shaded coffee plants have higher BCTB infestation compared to the tree under the sun due to the high level of canopy from shaded trees that provide a cooler and favorable environment for BCTB (Kagezi, et al., 2013). In addition, high agroforestry is the primary growing practice for coffee plantations in Uganda. Therefore, intercropping coffee plants with appropriate tree species with less canopy level may mitigate the BCTB infestation. Currently, climate change has become a concern worldwide. In sub-saharan africa, climate change has become a severe problem for coffee cultivation and needs efforts to sustain sustainable coffee production (Gebhart, 2017). Drought and extreme weather conditions are favorable to pest and disease, and further result in large yield losses and coffee quality degradation (Ogundeji et al., 2019). For instance, black coffee twig borer (BCTB) is more active during dry seasons in robusta coffee plantations due to weakened coffee plants caused by drought stress and water limitation (Hultman, 2016; Túler et al., 2019). Additionally, Ugandan coffee plantations highly rely on rainfall so that coffee farmers need to make more labor and economic effort to mitigate irrigation problems. However, with poverty and less financial support from local and relevant organizations, they still face the challenges of coffee production in terms of lack of irrigation, pest and disease and other relevant problems.

In addition to inadequate knowledge, information and training on BCTB identification and control methods for smallholder coffee farmers, the agricultural extension service is needed for farmers to control BCTB. In Uganda, agricultural extension officers guide farmers with necessary inputs and services regarding farmer training, demonstrations, group mobilization,

farm visits, sensitization meetings, exchange visits, field days, and study tours to enhance agricultural production (UBOS, 2022). However, according to the National Service Delivery Survey 2021 Report (NSDS), many households indicated that the extension service was insufficient due to various reasons.

Therefore, developing an effective method to control the BCTB for local farmers is urgently needed. One of the potential strategies is the push-pull method that leverages the plant signaling, repellents and pest attractants to manipulate pest behavior. Verbenone is a naturally occurring semiochemical that has been used as a repellent to protect trees and crops. For instance, it has been proven to be effective in protecting pine trees from bark beetles (Etxebeste & Pajares, 2011). Thus, this study will further examine the effectiveness of verbenone on BCTB control. Compared to traditional chemical pesticide control, the push-pull method is more environmentally friendly and cost-effective. This strategy has been proven to effectively control the maize stem borer in Ethiopia (Abate et al., 2024). However, this method requires knowledge of local pest behavior and it also needs regular monitoring to ensure trap crops are effective and not becoming sources of post multiplication. This research will focus on testing the feasibility of implementing push-pull methods in BCTB control in Uganda.

1.4. The objectives of the study

The study tested strategies for controlling black coffee twig borer (BCTB) under local conditions, contributing to sustainable robusta coffee production for smallholder farmers in Uganda. The two objectives of the study as followings:

- To assess the effectiveness of two repellents, verbenone and a combination of verbenone with methyl salicylate, in suppressing the Black Coffee Twig Borer (*X. compactus*) in smallholder coffee farms in Uganda.

- To survey perceptions of farmers and agricultural officers of BCTB infestation and further identify challenges and potential improvements in BCTB management strategies focusing on extension service delivery, climate change impacts, farming practices and fertilization etc.

2. Methodology

2.1. Study area and Field selection

In order to test strategies for controlling black coffee twig borer (BCTB) under local conditions to sustain robusta coffee production for smallholder farmers in Uganda,, tthis study was conducted in the Kamuli district, eastern Uganda, where the main coffee species is robusta coffee (*Coffea Canephora*). Additionally, this area is predominantly a smallholder farming region, and coffee production plays a critical role in the livelihoods of local farmers. However, these farmers face significant pest challenges, such as BCTB. Therefore, five small-scale coffee farms were selected in the sub-counties of Kavule, Kasaikye, Namasagali, and Buwaiswa for our field trial (Figure 3).

2.2. Semi-structured interview and online survey

To collect information about the knowledge of managing BCTB among local people, an online survey about strategies for BCTB management was conducted with 16 local agricultural extension officers using Google Forms, detailed questions are shown in **Appendix 1**. Meanwhile, a semi-structured interview (Adeoye-Olatunde & Olenik, 2021) was conducted with 10 coffee farmers in Kamuli by answering a list of open-ended questions (**Appendix 2**; **Figure 4**). Compared to structured or unstructured interviews, semi-structured interviews can better balance structure and openness, as well as collecting sufficient information. The challenges faced by farmers were investigated by letting farmers select from a list of potential challenges.

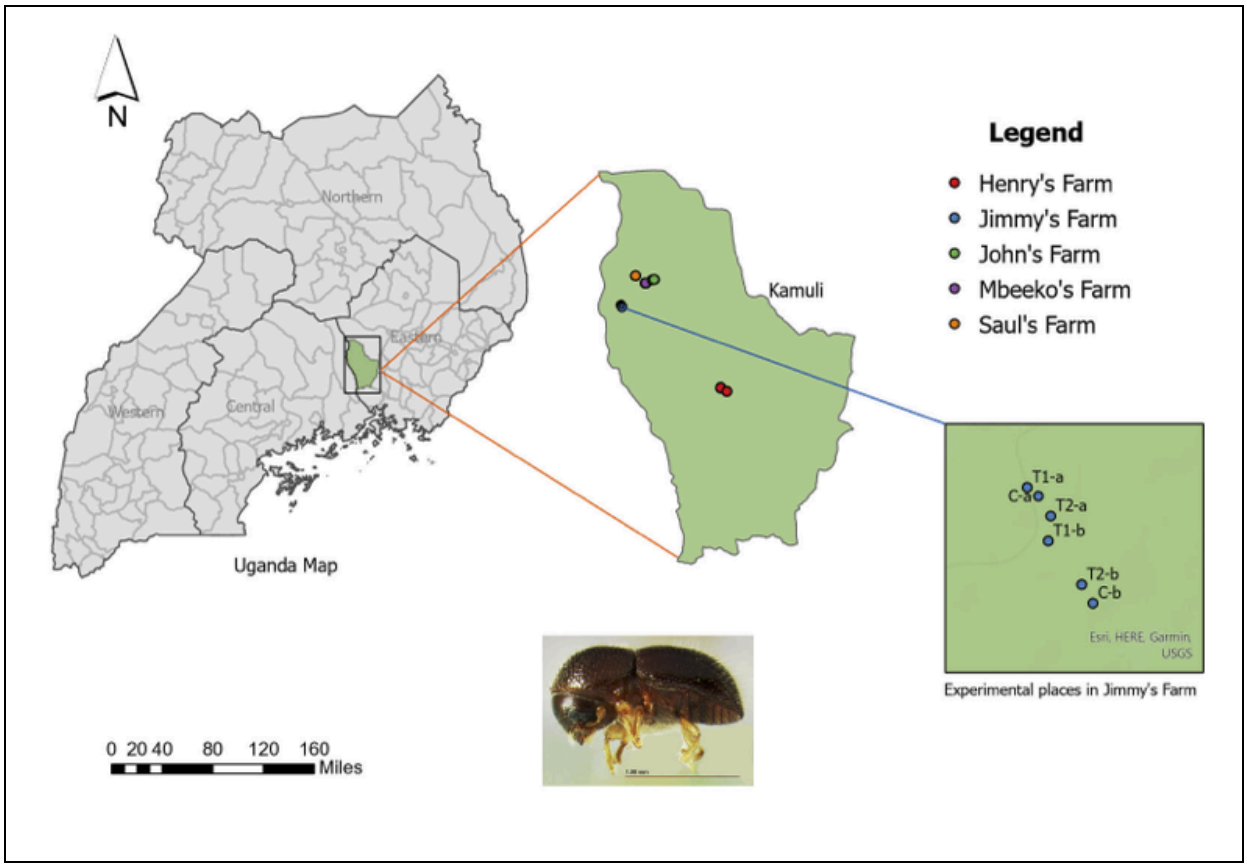

Figure 3. Study area in Kamuli district, Uganda.

Figure 4. Field interview with coffee farmers in Namasagali, Kamuli.

2.3. Field trial method

The field trial design of this study was based on a sustainable agricultural strategy integrated pest management (IPM), push-pull management reported by Cook et al. (2007). In push-pull management, repellents, often used in the form of natural plants or animals are typically applied to the main crop to 'push' away pests, while attractants are strategically deployed to 'pull' them towards attractant traps or trap crops, as shown in Figure 5 (Cook et al., 2007). This 'push-pull' dual-action strategy disrupts the pests' mating and feeding patterns, reduces their reproductive rate, and reduces crop damage and the need for chemical pesticides.

The push-pull system requires careful selection of repellents and attractants according to the target pest species and the specific crop. In this study, two naturally made compounds verbenone and methyl salicylate were used as repellents because they have proven effective to push ambrosia beetles away from the main crops in other studies (Burbano et al., 2012; Roy, 2023). According to several studies (Hanula & Sullivan, 2008; Lindgren, 1983), ethanol has been proved to be attractive for ambrosia beetles. Attractant traps like Lindgren funnel traps have been shown to be effective for monitoring and surveying invasive ambrosia and bark beetles (Lindgren, 1983; Burbano et al., 2012).

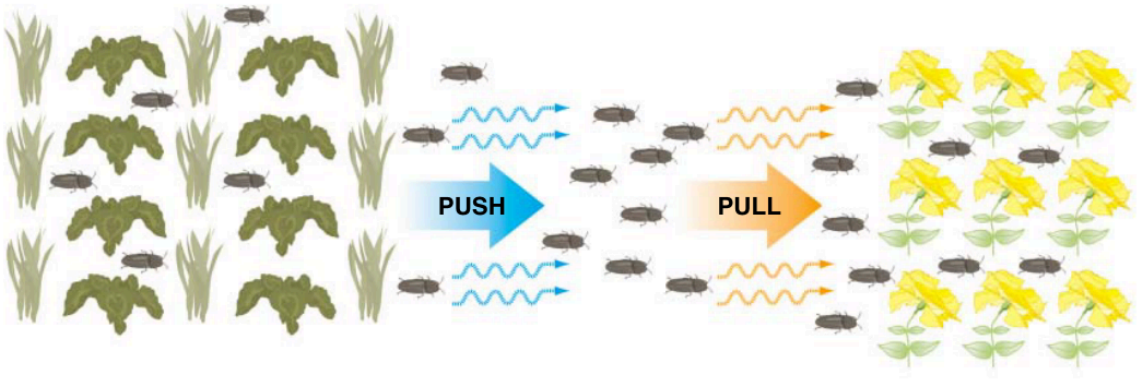

Figure 5. The mechanism of Push-pull strategy (from: Cook et al., 2007)

The field trial included two treatments and one control. The two treatments were represented by two types of repellent formulations, i.e. treatment 1 (T1): verbenone and treatment 2 (T2): a

combination of verbenone and methyl salicylate (including 10% verbenone + 10% methyl salicylate) applied to the main stem by a caulking gun in the amount of 2 gram of formulation per tree (Figure 7, a/b/c/d) based on the study by Roy (2023). Each treatment or control contained 8 replicates were divided across 8 plots (i.e, plot 1-8) in five different farms, each consisting of a 9-tree quadrant (**Figure 6**). To reduce the interactive impacts between plots, a distance of at least 30 m was maintained between plots, and the age of the selected tree ranged from 2 to 10 years old because this age of coffee tree is crucial for yield and is also susceptible to pests. The repellent was applied on each tree in the quadrant and was replaced every two weeks. The repellent compound was formulated into SPLAT (Specialized Pheromone and Lure Application Technology), a base matrix formulation composed of biologically inert materials (ISCA Technologies, Riverside, CA, reference). SPLAT is a wax-emulsion that facilitates the gradual release of active ingredients, such as pheromones.

Additionally, an attractant trap is an empty water bottle with two opposite cutted opens (Figure 7, e) containing a 150ml mixture attractant (50% Waragi + 50% water + one lid of liquid soap). The alcohol Waragi contains 40% ethanol and is locally produced and bought in a local shop in Kamuli town. The attractant trap was hung in the central tree of each replicate. This trap was used to assess the effect of the treatment on capture rates of BCTB. The attractant trap content was replaced every two weeks and captures analyzed. In the control (C), only an attractant trap was hung in the central selected tree without application of repellent.

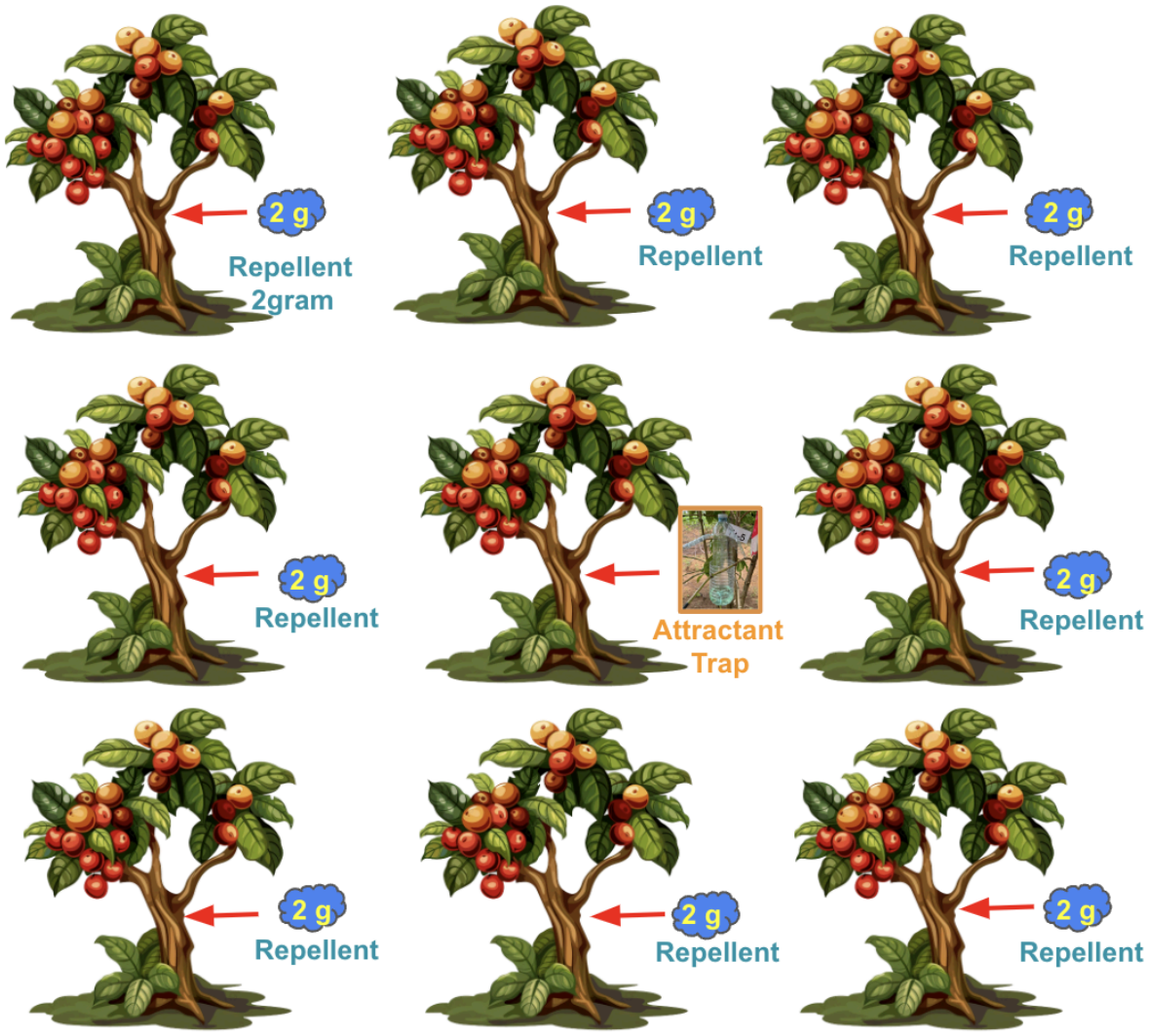

Figure 6. The experimental design in each replicate.

Figure 7. a, b - treatments formulated in SPLAT used for testing repellence of BCTB; c - application of treatments; d - a dollop on the main stem of coffee plant; e - attractant trap bottle; f - the marked ribbons on the experimental tree monitoring the infestation situation; g - a fresh entry hole on the intact twig (leaving this twigs on the

experimental tree after checking); h - entry hole on the dried twig(removing this twigs on the experimental tree after checking).

2.4 Monitoring and data collection

The data of BCTB infestation on the field was collected every two weeks with seven time points set as week 0, week 2, week 4, week 6, week 8, week 10, week 12. To ensure the validity of the test, the dried twigs and twigs with entry holes that are dried and completely blackened were removed after each data collecting time point. The entry holes on infested twigs are marked with different colors of ribbon (i.e, week 0- Black, week 2-pink, week 4-blue, week 6 -yellow, week 8-red, week 10-purple and week 12 green) while checking infestation.

The infestation level-related parameters evaluated in this study included total infested twig, infested dead twig, total new entry hole, infestation rate and shade level. The total number of infested twigs was calculated as the sum of newly infected living twig and infested dead twig removed during the same check time point. The dried twigs with entry holes were counted as infested dead twigs. The total number of new entry holes was counted during each investigation time point. The infestation rate for each tree within a replicate was calculated by dividing the total number of infested twigs during each time point by the total number of twigs before removal of dried twigs at the same time point. The shade level was scored visually from 1 to 5 with 1 representing no shade at all, 2 representing a low shade level, 3 representing medium shade level, 4 representing high shade level and 5 representing full shade. The Waragi mixture was collected and BCTB capture counted every two weeks using a microscope.

2.5 Data analysis

To evaluate the effect of two treatments (T1 and T2) compared to the control, multiple mean comparisons of the four parameters i.e. total infested twig, infested dead twig, total new entry hole and infestation rate were performed using the LSD post hoc test with the R package “agricolae”. Due to the noticeable local variation in infestation rates observed during investigation, the infestation rate data of the eight farm plots was also analyzed individually using mean ± standard error, where the standard error was calculated based on the nine independent trees of each plot. The impact of the factor time on the treatment effect on the four parameters was visualized in the form of line graphs. To explore the relationship between shade

level/intercrop species/age of coffee tree and infestation level, separately, the linear regressions were conducted between shade level (categorical data) intercrop species/age of coffee tree and infestation rate, and between shade level/intercrop species/age of coffee tree and total number of infested twigs.

3. Results

3.1. The effect of two repellents

The effect of different treatments on BCTB infestation were evaluated at the three most representative time points (i.e, week 2, week 6, and week 12; **Figure 8**). At week 2, the control treatment consistently exhibited the highest levels of infestation across total infested twigs, infested dead twigs, total new entry holes, and infestation rate. The T1 treatment significantly reduced the total infested twig (2.7) compared to the control (4.5), while the T2 treatment significantly reduced both the total infested twig (control: 4.5; T2: 2.8) and total new entry hole (control: 3.8; T2: 2.2). At week 6, T2 treatment showed a significant effect on reducing total infested twig (control: 2.3; T2: 1.3), infested dead twig (control: 0.5; T2: 0.2) and total new entry hole (control: 1.9; T2: 1.1) compared to control, while no significant effect was found with T1 treatment. At week 12, compared to control, no significant effect of either T1 or T2 treatment was noted. However, a trend of decreasing the total infested twig and total new entry hole was still visible.

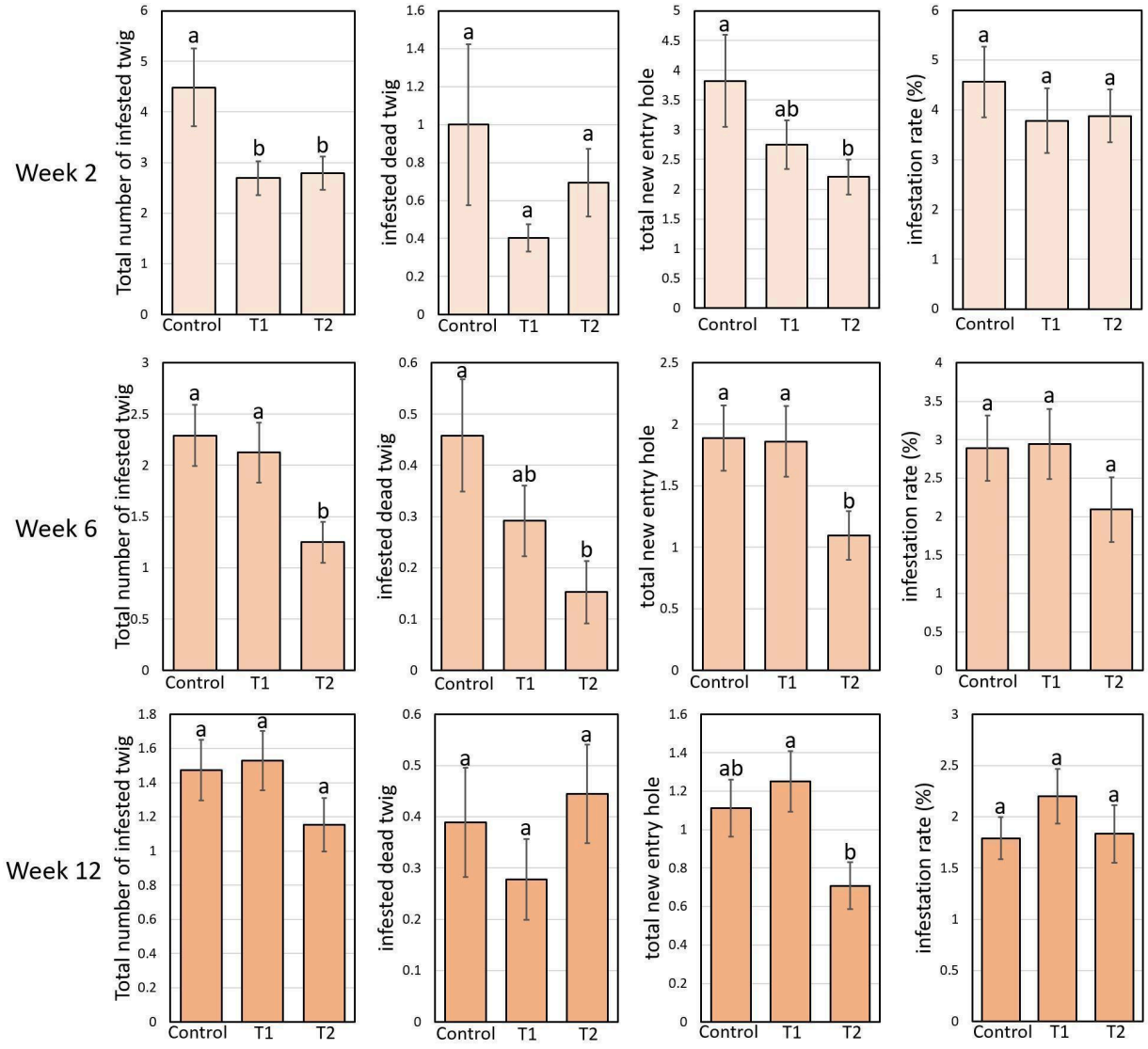

Figure 8. The average of infestation parameters of BCTB at three different time points (week 2, week 6 and week 12). T1 (treatment 1): verbenone and T2 (treatment 2): synergy of verbenone and methyl salicylate. Means between different treatments marked by the same letters do not differ significantly (LSD post hoc test at $p < 0.05$).

Considering the local environmental variation, such as temperature, humidity, shade level, and shade tree species between different experimental farm plots, this study also analyzed the infestation rate (%) of each farm plot individually. Large variations were found between farm plots, indicating strong environmental effects. At week 2, four and five farm plots showed a reduced infestation rate by T1 and T2, respectively. Most farm plots clearly displayed a reduction of infestation rate by both T1 and T2 at week 6, while this pattern disappeared at week 12, indicating that week 6 might be the time point with the maximum efficacy of both repellents.

T2 consistently resulted in lower infestation rates for plot 1, plot 3, and plot 6, while Treatment 1 was most effective for plot 4 and plot 5. The control group had fluctuating results, with generally higher infestation rates compared to the treatments, except in some instances like Saul, where T2 had the highest rate by week 12 (3.86 ± 0.87). In conclusion, T1 and T2 were effective in reducing BCTB infestation compared to the Control. T2 generally showed more consistent effectiveness across different farms, with larger reductions in infestation rates over time. T1 also demonstrated effectiveness, particularly in the case of plot 4 and plot 5, but was slightly less consistent than T2.

Table 1. Average infestation rate (%) ± standard error of each farm plot under different treatments and the change of infestation rate relative to Control at 3 time points, i.e. week 2, week 6 and week 12. Change rate to control = (infestation rate under treatment - infestation rate under control)/infestation rate under control.

	Plot	Control	Treatment 1	Treatment 1 change rate to Control (%)	Treatment 2	Treatment 2 change rate to Control (%)
week 2	1	5.89 ± 2.96	6.10 ± 1.52	3.57	4.25 ± 1.29	-27.84
	2	1.34 ± 0.48	4.79 ± 2.26	257.46	2.84 ± 0.71	111.94
	3	3.98 ± 0.78	6.66 ± 3.87	67.34	3.00 ± 0.54	-24.62
	4	3.35 ± 0.81	3.43 ± 0.68	2.39	2.38 ± 0.86	-28.96
	5	10.20 ± 3.85	2.37 ± 0.87	-76.76	4.56 ± 2.13	-55.29
	6	2.24 ± 0.43	0.76 ± 0.32	-66.07	1.14 ± 0.38	-49.11
	7	3.16 ± 0.92	1.88 ± 1.37	-40.51	4.76 ± 1.53	50.63
	8	6.37 ± 1.76	4.27 ± 1.14	-32.97	8.08 ± 2.54	26.84
week 6	1	3.22 ± 0	8.10 ± 1.93	151.55	1.27 ± 0.73	-60.56
	2	6.99 ± 0.12	6.04 ± 1.57	-13.59	5.32 ± 2.01	-23.89
	3	2.13 ± 0	3.38 ± 0.97	58.69	1.24 ± 0.48	-41.78
	4	1.49 ± 0.05	0.37 ± 0.15	-75.17	1.02 ± 0.49	-31.54
	5	3.02 ± 0	1.22 ± 0.49	-59.60	1.73 ± 0.54	-42.72
	6	1.68 ± 0	0.60 ± 0.19	-64.29	0.92 ± 0.50	-45.24
	7	1.96 ± 0	1.58 ± 0.42	-19.39	2.51 ± 1.62	28.06
	8	2.65 ± 0	2.28 ± 0.80	-13.96	2.73 ± 1.64	3.02
week 12	1	2.39 ± 0.53	4.13 ± 0.61	72.80	1.22 ± 0.48	-48.95
	2	1.94 ± 0.59	3.13 ± 0.74	61.34	2.27 ± 0.85	17.01
	3	0.49 ± 0.26	2.02 ± 1.23	312.24	0.66 ± 0.37	34.69
	4	1.04 ± 0.72	0.78 ± 0.39	-25.00	1.29 ± 0.64	24.04
	5	2.22 ± 0.46	0.94 ± 0.40	-57.66	1.63 ± 0.50	-26.58
	6	2.17 ± 0.68	1.43 ± 0.59	-34.10	1.72 ± 1.12	-20.74
	7	1.82 ± 0.61	2.01 ± 0.68	10.44	2.02 ± 1.04	10.99
	8	2.26 ± 0.65	3.16 ± 0.64	39.82	3.86 ± 0.87	70.80

All treatments showed a trend of decreasing the number of affected twigs over time (Figure 9). T1 showed a lower total number of infested twig and total new entry hole than the control at week 2 but this difference disappeared since week 4, indicating that T1's effectiveness did not last long. On the other hand, T2 consistently showed a lower total number of infested twig and total new entry holes than both control and T1 treatment over the 12-week period.

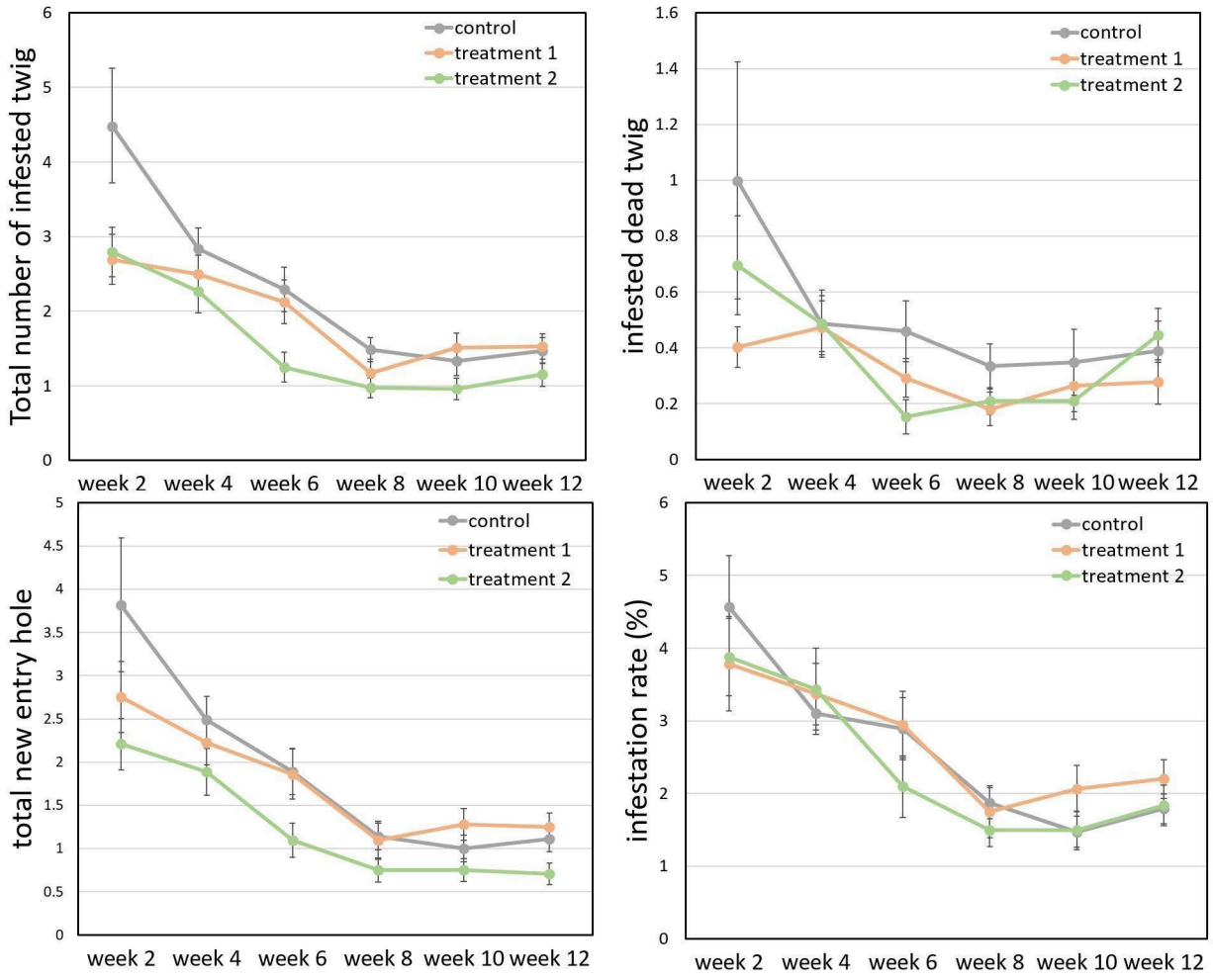

Figure 9. BCTB infestation in three treatments over time (week 2, 4, 6, 8, 10 and 12)

3.2. The relationship between shade level and BCTB infestation rate

The linear relationship between shade level of coffee trees and the BCTB infestation rate on 8 replicates of 3 treatments at week 2, 6 and 12 are presented in **Figure 10**. In the control, no significant correlation was found at early investigation time points (week 2 and 6), while the

shade level showed a significant and positive correlation with infestation rate at week 12. Interestingly, T1 and T2 treatments showed different correlation patterns between shade level and infestation rate. Shade level was significantly and positively correlated with infestation rate under T1 treatment (a positive trend but not significant in week 12). On the contrary, no significant linear relationship was found between shade level and infestation rate under T2 treatment.

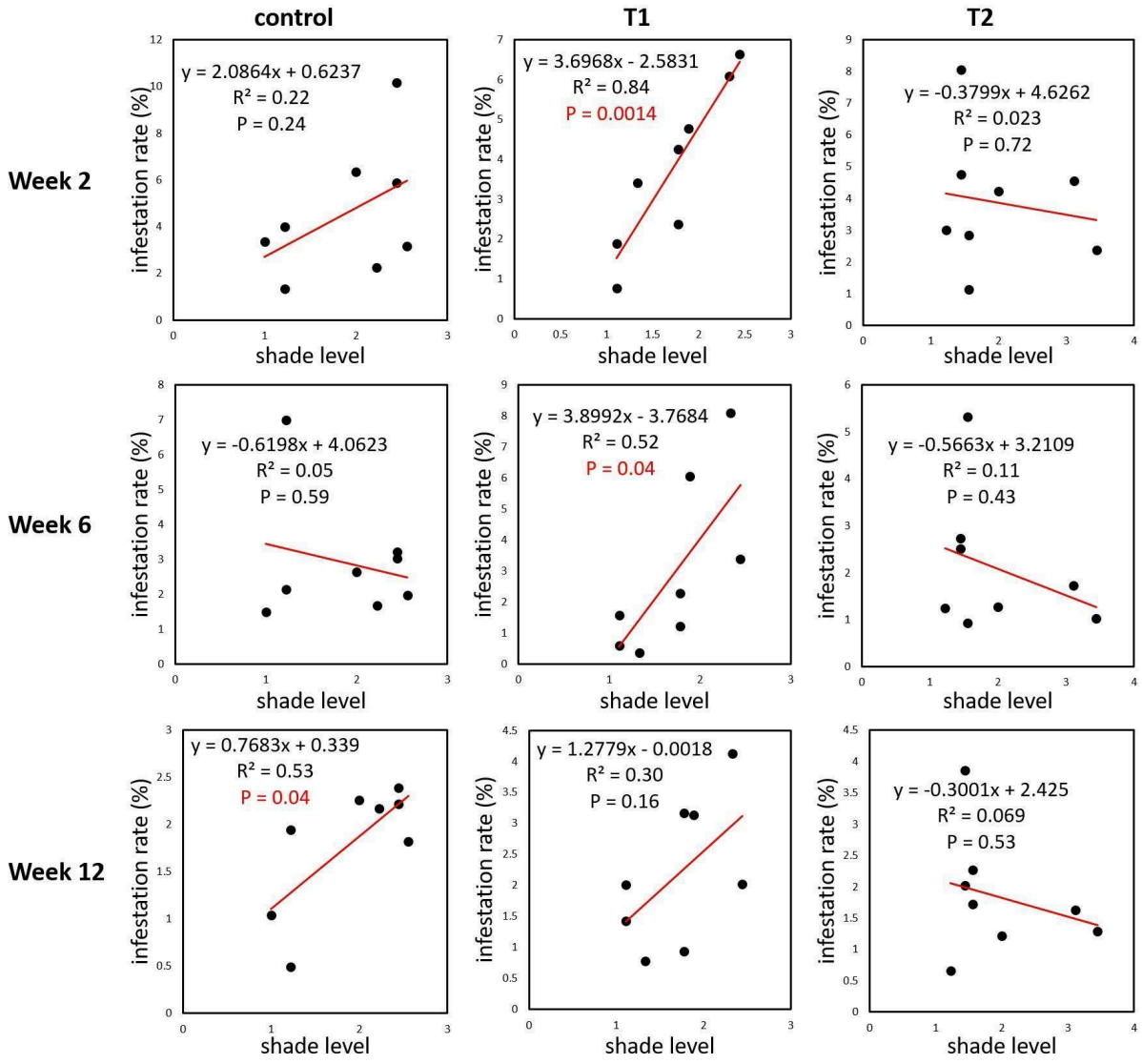

Figure 10. The linear relationship between BCTB infested rate and Shade level on 8 replicates of three treatments (control, T1 and T2) at week 2, 6 and 12.

3.3. The number of BCTB captured

The average number of BCTB captured by attractant traps is presented in **Figure 11**. The number of captured BCTB fluctuated largely due to some random effect, which made it difficult to draw a conclusion from it. However, a trend could be seen from the data. The traps in the control captured a higher number of BCTB than T1 and T2 treatments at week 2 and week 4 (Figure 9). During later stages, no difference in the number of captured beetles was found between control and treatment groups (T1 and T2). The BCTB capture rate in this experiment was generally very low due to low attractiveness of the attractant.

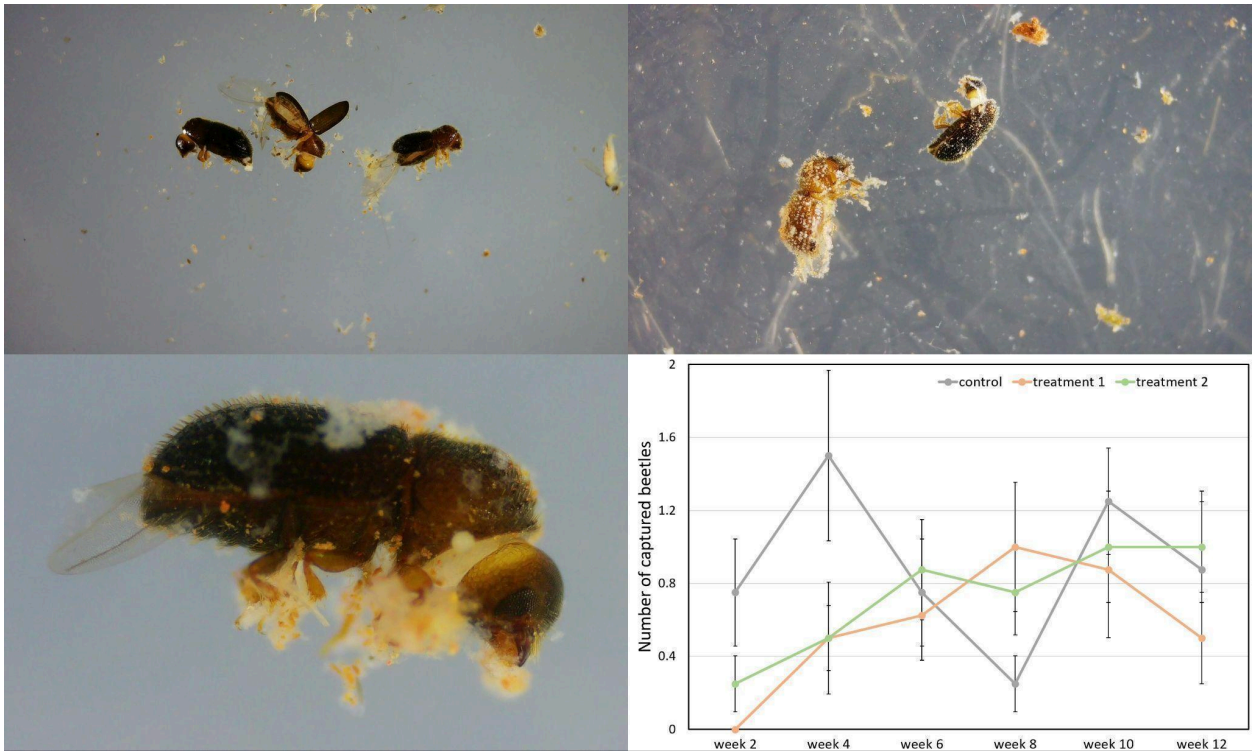

Figure 11. The captured BCTB in attractant combined traps and the average number.

3.4. The relationship between intercrop species/age of coffee tree and BCTB infestation

After conducting the linear regressions between intercrop species/age of coffee tree (categorical data) and infestation rate, and between intercrop species/age of coffee tree and total number of infested twigs, no correlation was found between intercrop species/age of coffee tree and infestation rate and the total number of infested twigs.

3.5. Interview/online survey results on perceptions of farmers vs extension officers of BCTB infestation status

3.5.1. Pest and disease

3.5.1.1. The presence of BCTB for coffee plantation

The occurrence of BCTB is mainly concentrated in the dry season. The government's concern about the impact of BCTB was rated 5.6 (out of 10), while the majority (81%) of extension officers expected to reduce the spread of BCTB through more effective management and research. Farmers believed that the BCTB-induced coffee yield loss was estimated around 38%, while extension officers expected it to be 52% .

All agricultural extension officers in Kamuli named BCTB as the most common pest. The majority of them (75%) further mentioned that BCTB had a larger economic impact compared to other pests and diseases (**Figure 12**).

Farmers reported that they observed pests and diseases during coffee cultivation, especially BCTB. Some farmers detailed what they have found in the past few years, including BCTB and other fungal diseases causing blackened coffee beans and leaves. This suggests that BCTB is a common problem in local coffee cultivation. Ninety percent of interviewed farmers encountered BCTB problems. They also mentioned other pests or diseases that they were unable to identify. All coffee farmers explicitly mentioned a decline in coffee production due to pests and diseases.

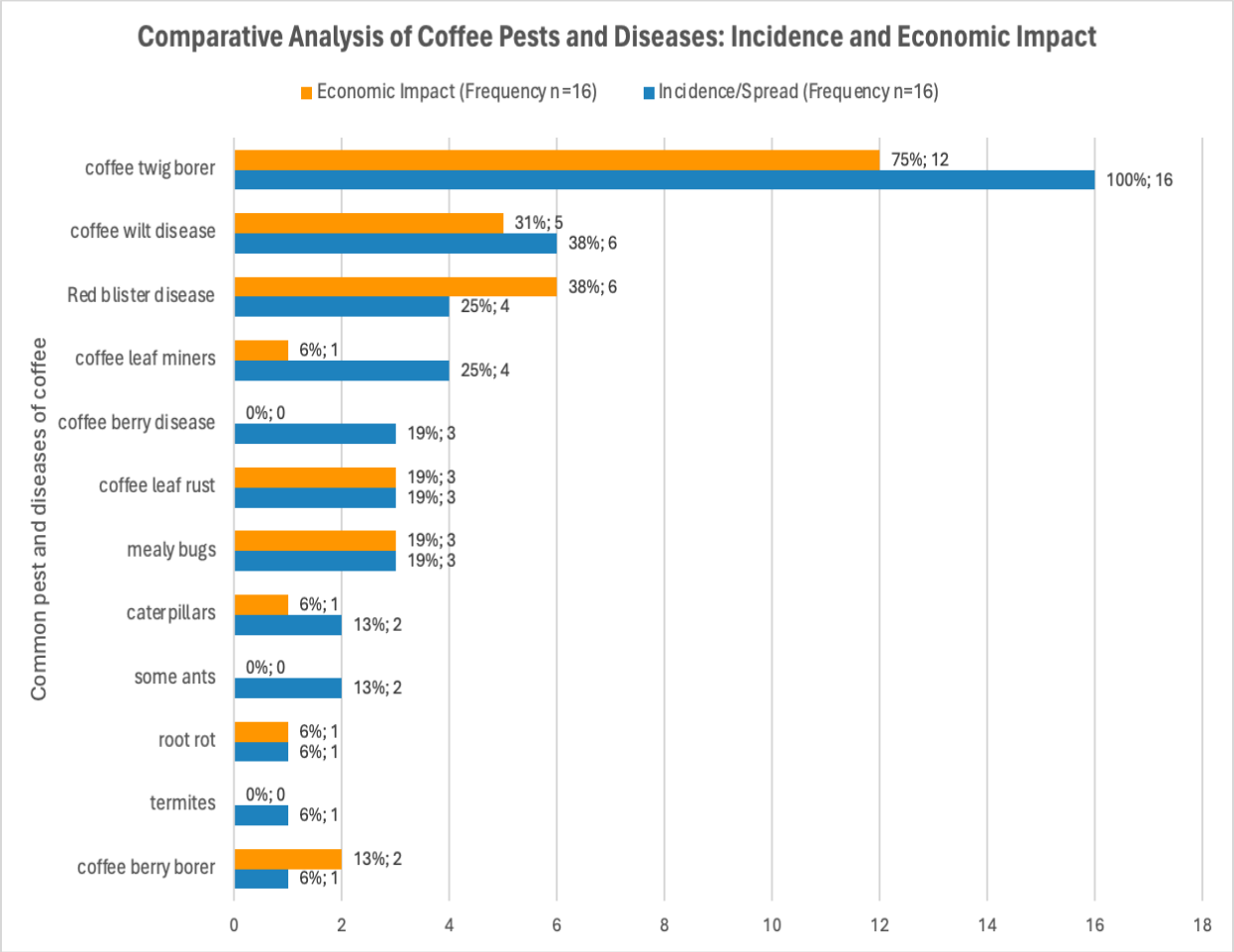

Figure 12. The common pests and diseases of coffee plantation from perspective of extension officers in Kamuli

3.5.1.2 Awareness of BCTB infestation by farmer and extension officers

Although BCTB is widely mentioned as a major pest, some farmers were still uncertain about whether a symptom belongs to BCTB or some other pest. Almost all the farmers interviewed reported that they face pest problems during their coffee farming (Table 2). Entry holes on twigs (80%), drying of twigs (80%) and wilting of leaves (50%) were mentioned most commonly. Wilting of twigs (30%) and leaf dryness (40%) were also frequently mentioned. Falling of leaves (10%), blackening of leaves (10%), visible pest in twigs (10%) and visible pest eggs in twigs (10%), although less frequent, were still important symptoms potentially caused by diseases and pests. Note that these observations require a higher recognition ability and require time consuming examinations. The result showed a large diversity of symptoms mentioned by different farmers.

Table 2. Interview results about pest/disease-infested symptoms/signs of coffee plants reported by coffee farmers in Kamuli district, Uganda.

Investigate object	Symptoms	Frequency	Percentage %
Farmers (n=10)	entry holes on twigs	8	80%
	drying of twigs	8	80%
	drying of leaves	4	40%
	wilting of leaves	5	50%
	wilting of twigs	3	30%
	falling of leaves	1	10%
	blackening twigs	1	10%
	seeing the pest inside the twigs	1	10%
	seeing the eggs of the pest inside the twigs	1	10%

From the perspective of extension officers, entry hole (44%), drying twigs (63%) and wilting twigs (31%) are the most frequently reported symptoms ,while blackening of twigs (13%), borer/larva (13%), drying of leaves (13%), premature berries (13%), drying of berries (19%) and falling of premature berries (13%) were also mentioned less frequently. dieback of twigs (6%), blackening of leaves (6%), yellowing of leaves (6%) and death of plant tissue (6%) were least observed symptoms (**Table 3**).

Table 3. Online results about BCTB-infested symptoms/signs of coffee plants reported by extension officers in Kamuli district, Uganda.

Investigate object	Symptoms	Frequency	Percentage %
Extension officers (n =16)	entry hole on twigs	7	44%
	drying of twigs	10	63%
	wilting of twigs	5	31%
	dieback of twigs	1	6%
	blackening of twigs	2	13%
	borer/larva into twigs	2	13%
	blackening of leaves	1	6%
	drying of leaves	2	13%
	yellowing of leaves	1	6%
	death of plant tissue from entry hole	1	6%
	premature berries	2	13%
	drying of berries	3	19%
	falling of premature berries	2	13%

	powdery substance seen at entry hole	1	6%

3.5.1.3 The changes of BCTB infestation over time

There was a noticeable disparity of perceptions between farmers and extension officers. Farmers mainly (60%) believed the BCTB infestation had reduced compared to previous years, because they observed less yield losses and applied recommended practices such as removing and burning infested twigs and plants. At the perspective of surveyed extension officers, more than half of them stated that BCTB infection has either increased or greatly increased (**Figure 13**). They thought that coffee farmers lacked knowledge and information for BCTB management strategies, and the adoption of new practices and management strategies was low, as well as planting less pest-resistant seedling material, and intercropping BCTB host trees in the coffee gardens etc. On the contrary, 31% extension officers stated that the BCTB infestation was reduced or greatly reduced. They believed that the awareness of BCTB had increased so that some farmers already took practices to control BCTB, and the BCTB infestation was already reduced naturally.

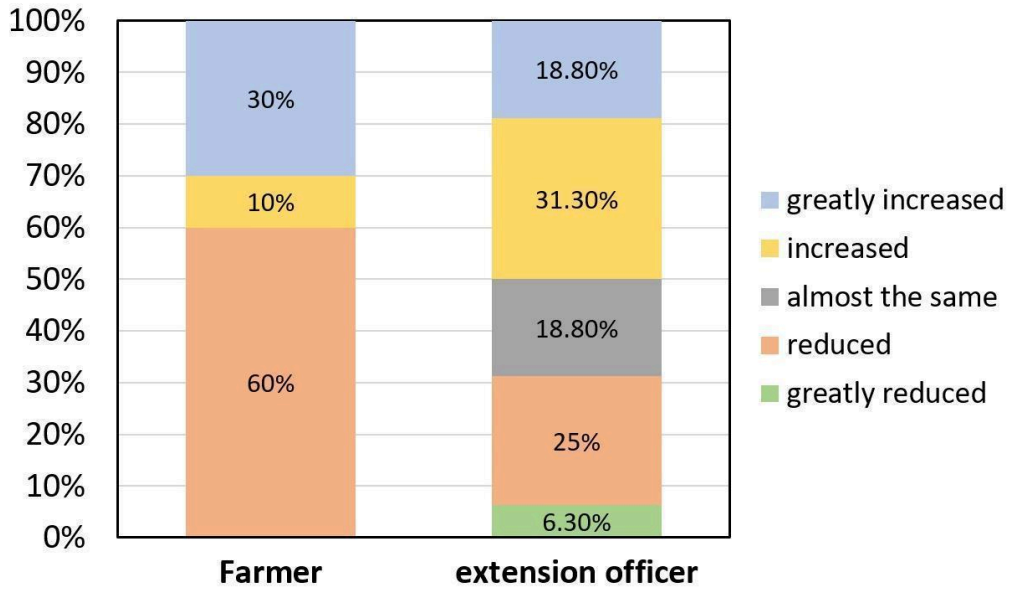

Figure 13. The survey on changes in BCTB infestation levels compared to previous years, coffee farmers' opinion (left) and agricultural extension officers' perception (right)

3.5.1.4 Comparison of BCTB Management Perspectives: Extension Officers vs. Coffee Farmers

Farmers and extension officers differ in the approaches they mention to manage BCTB infestations. The majority of the extension officers (81.3%) advocated a comprehensive, integrated pest management (IPM) approach that combines cultural, physical, and chemical methods (**Table 4**). The recommended cultural control included removing and destroying infected branches by composting, burning, removing field weeds, and proper pruning. Physical methods included using insect traps made from clear plastic bottles or small medicine bottles. Chemical control involved using recommended pesticides such as imidacloprid. Avoiding and removing BCTB host tree species was also encouraged. Additionally, 56% pointed to the existence of government directives on BCTB control, including the use of non-harmful planting materials, regular field inspections, and pruning infected branches.

Farmers focused more on practical, immediate actions to manage BCTB (Table 5). The most common control measure was the removal of infected branches, used by all the farmers. Further, 90% of farmers chose to burn infected branches to ensure complete elimination of pests and diseases. 30% farmers preferred to maintain plant health by pruning and reducing branches or weeding. Other measures that were mentioned included fertilization (10%), cutting down infested trees (10%) and using government-provided pesticides (10%) to reduce pest incidence.

Table 4. Online survey results of BCTB management strategies reported by extension officers in Kamuli.

Special management measures for BCTB
Remove and destroy infected branches
Reduce shade and avoid dragging wood in the coffee garden.
Avoid using host tree species of BCTB. Inspect the field regularly. Use traps
Remove the weeds, trim them properly, and burn the infected branches.
Plant recommended shady tree species that do not attract pests.
Keep good field hygiene, use chemical control such as imidacloprid.
Remove dry branches and excessive shade.
Use the recommended insecticide, remove and burn infected branches.
Plant Albicia (Albizia), and grow healthy plants in certified nurseries.
Trim the coffee garden, remove and incinerate the infected branches, and spray them with imidacloprid (120 ml/ 20l).
Use the insect traps.

Table 5. Interview results of BCTB management strategies reported by coffee farmers in Kamuli.

management	Frequency (n=10)	percentage
Remove the infested branches	10	100%
Burning the infested branches	9	90%
Manage coffee plants (pruning, reduce branches)	3	30%
Weeding	3	30%
Applying manure	1	10%
Cut down the whole infested tree	1	10%
Spraying the pesticides got from local government but stopped later	1	10%

3.5.2 Intercropping trees/crops for coffee cultivation

3.5.2.1 Awareness of BCTB infestation situation under shade tree vs non-shade tree by farmer and extension officers

Based on the interview results, 80% of coffee farmers and 50% of extension officers both reported that coffee grown under shade trees had higher BCTB infestations compared to non-shaded trees (**Figure 14**). Majority farmers don't know why the tree under the shaded tree has higher BCTB infestation. 50% of agricultural extension officers reported coffee grown under shaded tree had higher BCTB infestation because shaded tree can be alternative host for BCTB and its canopy provide cool and favorable environment for BCTB. 25% of extension officer has opposite opinions, they reported that non-shaded coffee had warmer climate which is favorable for BCTB and shaded-tree that are not host for BCTB can prevent the tree infested by BCTB.

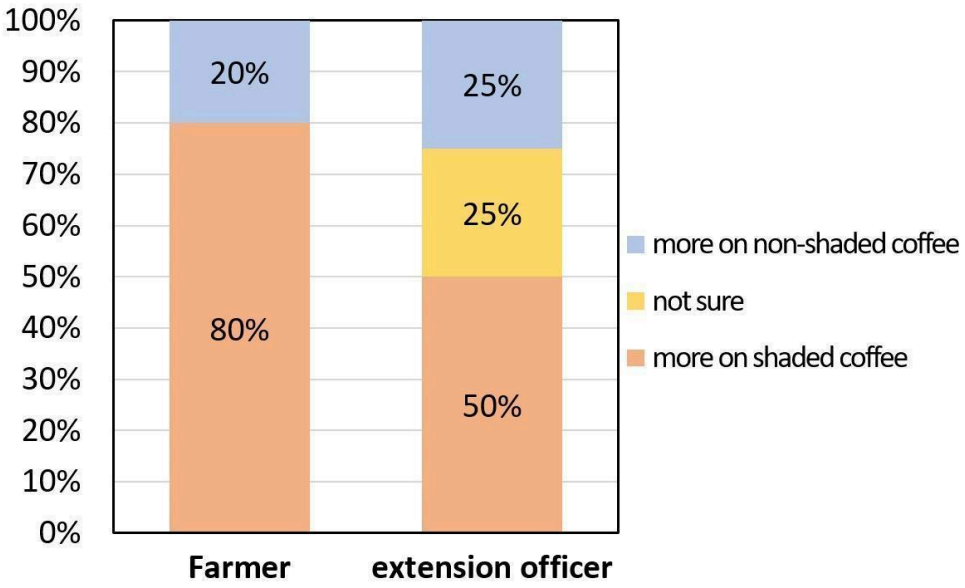

Figure 14. the infestation under shade tree vs non-shade tree, farmers' opinion (left) and extension officers' opinion (right)

3.5.2.2 Intercropping crop species selected by coffee farmer vs extension officer

The shade trees for coffee cultivation recommended by extension officers differed from those grown by coffee farmers (**Figure 15**). Four farmers' selections matched with official recommendations, i.e. banana, legumes, *Ficus Natalensis* and *Musizi*. However, the other six recommended species i.e. *Albizia*, *Grevillea*, vallina, elephant grass, *Acacia* and *Markhamia* Lutea were not mentioned by the interviewed farmers, while seven out of eleven farmer-selected intercropping species (i.e. jackfruit, maize, mango, cocoa, cassava, orange and avocado) were not mentioned by extension officers' recommendation (Figure 13). Banana was found to be the most popular species among both farmers (100%) and extension officers (56%). Surprisingly, jackfruit (80%), maize (60%) and mango (60%) were also largely welcomed by farmers but not recommended as intercropping.

The consideration when selecting the intercropping shade crop appeared to differ between farmers and extension officers (**Table 6**). Farmers tended to choose intercropping crops for realistic reasons such as shading (100%), home consumption (70%), firewood (60%), income (50%), timber (50%) and animal feed (20%), etc, while extension officers tended to recommend

based on scientific reasons such as nutrients increase (38%), soil erosion avoidance (13%), soil fertility improvement (13%) and weed control (6%).

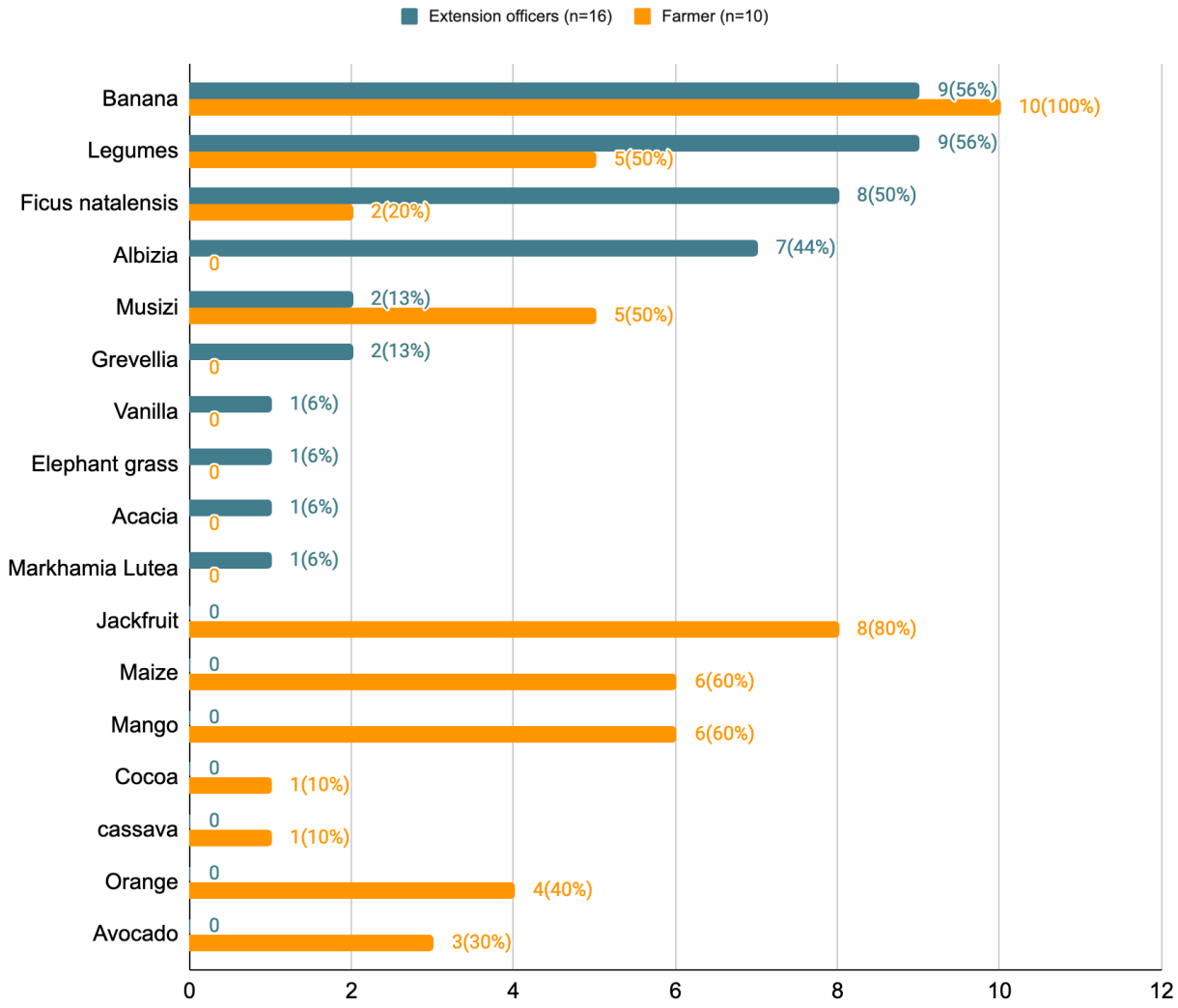

Figure 15. The species of intercrops actually intercropped with coffee plantations by interviewing farmers and recommended species of intercrops with coffee by extension officers.

Table 6. Considerations by farmers and extension officers when selecting intercrops in coffee cultivation (n=10) & extension officers (n=16)

Investigate object	Purpose of Intercropping	Frequency	Percentage (%)
Farmer (n=10)	Shading	10	100%
	Home consumption	7	70%
	Firewood	6	60%
	Getting income	5	50%
	Timber	5	50%
	Manure (fertility)	4	40%

Investigate object	Purpose of Intercropping	Frequency	Percentage (%)
	Animal feed	2	20%
	Bark cloth	1	10%
	Native tree	1	10%
	Remain moisture in soil and reduce water lacking	1	10%
Extension officers (n=16)	Provide nutrients for crops/symbiotic relationship /Nitrogen fixation	6	38%
	Provide shade/ Canopy	4	25%
	Increase income for household	4	25%
	Don't be alternative host for pest	4	25%
	home consumption food	3	19%
	Cover crop to reduce soil erosion and keep moisture	2	13%
	Increase soil fertility	2	13%
	Reduce competition	1	6%
	Controlling weed	1	6%

3.5.3 Challenges of coffee plantation

3.5.3.1 Challenges faced by coffee farmers

In the interview, the interviewed farmer scored the challenges from 1 to 10, where 1 represented a low level of challenge while 10 represented a high level of the challenges. Clearly, most farmers perceived diseases and pests as the major challenge for coffee cultivation (7.7), followed by road access (7.0 points; Figure 16). Extension service delivery came as the third biggest challenge (6.9 points) Water supply and effective irrigation systems were other significant challenges with a mean of 6.4. The points of both proper returns (5.1) and marketability and selling (4.0) were highly scattered, with the lowest and highest being 1 and 10 points, respectively. The score of soil quality (4.9 points) reflected farmers' concerns about soil quality. Theft problems had the lowest score, with a mean of 3.2 points.

According to extension officers, pests and diseases pose the most significant challenge for coffee farmers (**Table 7**). The Black Coffee Twig Borer (BCTB) is a particularly severe pest in coffee plantations, and identifying and managing it is a pressing concern in Kamuli District. Additionally, drought and the high cost of inputs such as chemicals and seedlings were also reported as key challenges faced by farmers.

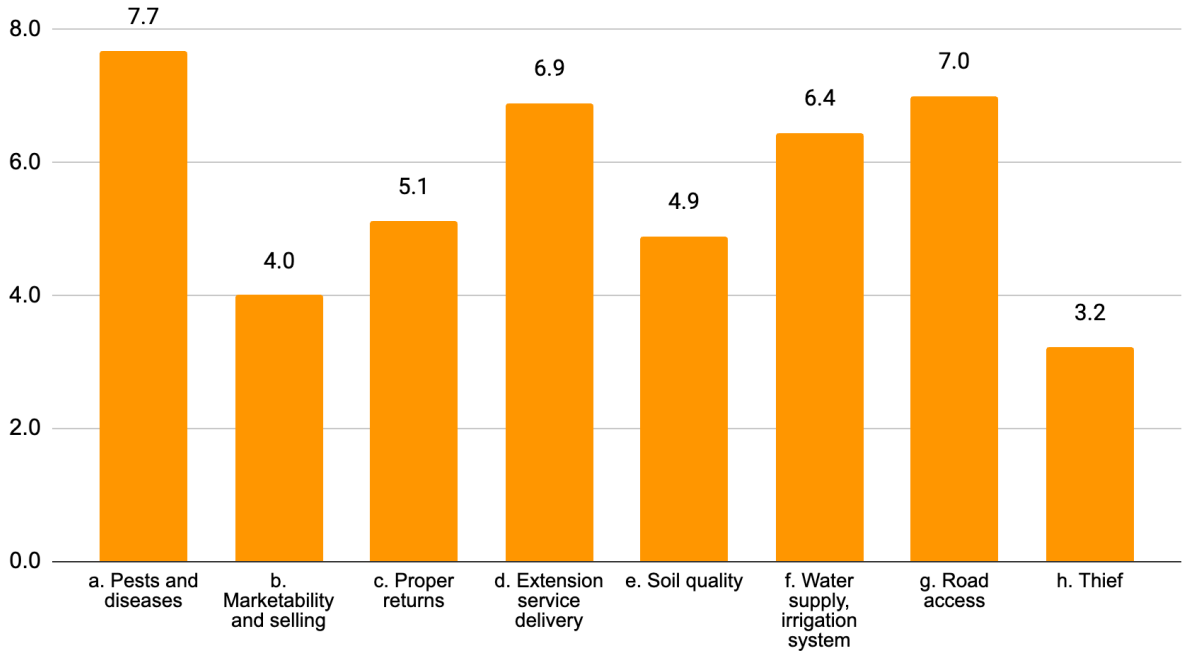

Figure 16. The answers on challenges faced by coffee farmers (score range from 1 to 10, value closed 1 means low level of challenge which value closed to 10 means high level of challenge)

Table 7. Online survey results about the challenges of coffee plantations reported by extension officers in Kamuli.

Object	**Problems of coffee plantation**
Extension officers(n=16)	Pests and diseases identification
	how to manage BCTB issue
	pesticide usage to control BCTB
	good agronomic practice need to be improved
	production reduction
	pest and diseases issues, (BCTB/blister)
	low fertility field
	coffee price fluctuation
	how to get quality seedling
	cost of agro chemicals
	drought
	how to increase coffee productivity

3.5.3.2 Agricultural extension delivery

The survey results showed that the majority of farmers (70%) did not join any association, cooperative, or group, indicating that farmers tend to work independently instead of working cohesively in coffee-growing communities.

Farmers' had different assessments of the accessibility of government promotion services than extension officers (**Figure 17**). Only 20% of interviewed farmers thought accessing services was easy, while 60 % found it difficult, or had doubts about the quality and effectiveness of the services. In contrast, the majority of extension officers (75%) believed that farmers could access extension services easily, revealing a gap of perspective on this issue between farmers and extension officers.

Table 8 presents insights from an online survey regarding improvements needed in BCTB management and agricultural extension service delivery from the perspectives of both farmers and extension officers. Farmers were mainly recommended to improve their own skills and work quality such as adopting better post-harvest procedures, monitoring fields more regularly, timely planting, proper spacing and actively attending training. Suggestions to local government mainly focused on providing necessary support to improve infrastructure and secure extension service quality. Moreover, this list also showed some common areas of improvements that needed joint efforts from both farmers and local governments. For instance, farmers were recommended to organize and actively attend FFF (farmer field school) and field days, which also needed strong support from the local government. Farmers were encouraged to learn to use digital tool i.e. WhatsApp and Zoom to acquire extension services, while the government needed to support technological improvements that facilitated remote extension service delivery.

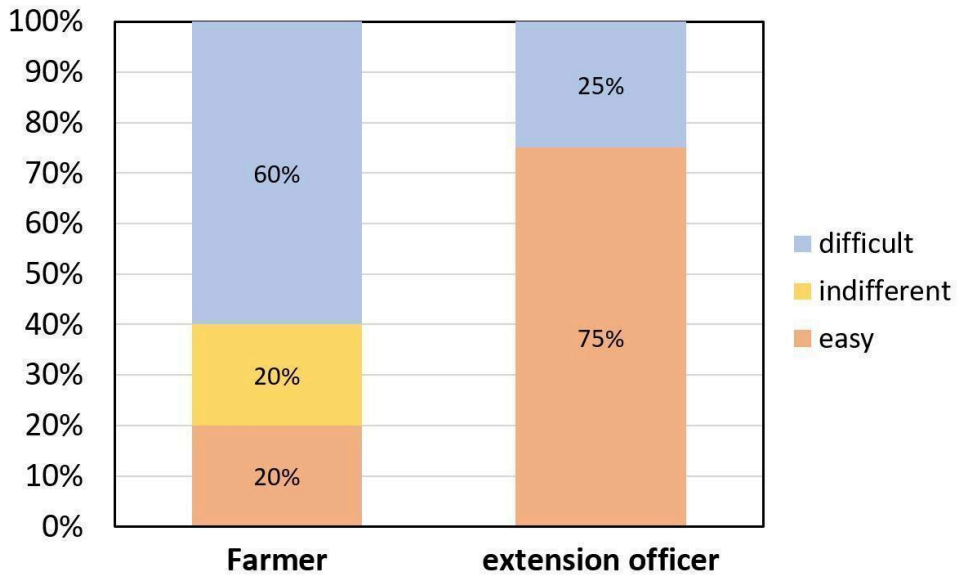

Figure 17. The situation of access to extension service from government, farmers' perspective (left) and agricultural extension officers (right)

Table 8. Online survey results about improvement of agricultural practice and extension delivery reported by extension officers in Kamuli.

Coffee Farmer Side	**Local Government Side**
Improvement on disease resistant varieties and post harvest handling procedures	More capacity building of extension officers
Paying more attention in monitoring their coffee fields	Facilitation in terms of movement to the field (motorbikes)
Adopt coffee stumping and growing of disease resistant varieties released by research institute (NACORI)	Add more extension staff
Timely planting, proper spacing, attending trainings	Provision of enough fuel on time and inputs e.g fertilizers to those active farmers
Put into practice what has been trained/to do it persistently	Reduce the extension/farmer ratio. At Least add another extension staff in the sub county
The farmers should adopt new technologies	Establish farmer field school and Field days.
Recruit extension workers at sub-county level	Increase fuel for extension workers and increase monitoring
They should form groups	Increase the number of extension staff.
having more FFS(farmer field school) and Field days	forming more farmer groups, forming more FFS and field days
Farmers need to go digital in accessing extension services e.g use of WhatsApp, zoom, etc	provides enough fuel to offer extension services therefore farmers have to show interest and request for the services
Continuous trainings in mindset change, demo sites established , farmer organizations empowered	Timely acquisition of fuel and facilitation Enough demo materials to be availed Establishment of well facilitated farm field schools
More support with inputs for demonstration gardens setup and managed by extension officers.	Supporting establishment of demo gardens to be directly managed and supervised by Extension officers.
Practice of cultural practices to manage pests and diseases.	Provision of means of transport and more fuel for transportation

	to cover more farmers.
Improve facilitation of government extension workers so as they increase their coverage	Technological improvements to facilitate remote extension methods for farmers
Minimum supervision of the extension workers to ensure they provide good service	Increasing the number of extension workers
Increase the number of extension services to match the increasing demand	The government should recruit extension assistants at parish level

4. Discussion

4.1 Challenges on BCTB management for coffee farmers in Uganda

4.1.1 BCTB infestation and its challenges for smallholder coffee farmers

In Uganda, agriculture plays a crucial role in the economy of the whole country, and coffee production contributes a large proportion of export earnings in agriculture sectors (ICO, 2019). Coffee is mainly grown in small farms under the size of 0.25 hectare land, which provided the main source of income for over 1.7 million coffee smallholders in Uganda (ICO, 2018). Unfortunately, approximately 30% of coffee smallholders could not afford daily food and their average income is estimated 0.85 USD per capita per day under the half international poverty line. Even so, income of coffee-grown households was 10 % more than non-coffee growing households (Bunn et al., 2019). These smallholder coffee farmers faced a lot of challenges to increase coffee yield at farm level to get more incomes and improve their livelihood. As mentioned by interviewed coffee farmers and agricultural extension officers in Kamuli district, coffee farmers faced challenges mainly involving pest and disease, drought, extension service delivery and transportation, low soil fertility and cost of agricultural inputs.

Regarding these challenges, the Black coffee twig borer (BCTB) is the major threat for smallholder coffee farmers to decrease the coffee productivity. According to the interviewed farmers and surveyed extension officers in Kamuli district, the estimated coffee yield loss caused by BCTB were 37.5% and 51.8%, respectively. In Uganda, BCTB has become a serious problem over the past decade and it is rapidly spreading in various coffee cultivation regions, especially for robusta coffee (UCDA, 2012). In history, BCTB caused serious infestation for coffee

plantations in Mukono and Kayunga districts in the central region in 2008, which led to 37.5% interviewed robusta-grown farms being infested (Egonyu et al., 2009). In 2013, 68.8% of coffee plantations were infected by BCTB in 26 districts across Uganda (Kagezi et al., 2013c). BCTB affects both the quality and quantity of coffee production, and further impact on rural livelihoods and export revenue.

4.1.2 Challenges on agricultural extension services delivery

In the interview and online survey of this study, the poor awareness and knowledge for identifying and managing BCTB was found to be a key issue for coffee farmers. For example, the majority interviewed coffee farmers did not recognize classical BTCB symptoms as BCTB infestation or other pests or disease even though they noticed some symptoms of coffee plants such as blackening and drying twigs and leaves, suggesting inadequate knowledge and recognition of pests and diseases among these farmers. Exploring the deep reasons of the situation, agricultural extension services involving delivery information, knowledge and financial services need to be improved (Christoplos, 2010).

In Uganda, agricultural extension services to share knowledge, technology, risks, farm practices and also help farmers with the necessary inputs to support their agricultural production, which involves farmer training, group mobilization, farm visits, sensitization meetings, field days etc. (UBOS, 2022). However, the access to the agricultural extension service has many problems due to rural settings, such as lack of affordable internet services and limited financial use of digital devices (Kansiime et al., 2022). This study found that almost all the interviewed farmers learned about BCTB from radio channels, such as talk shows in KBS and Basoga One and local extension workers.

Besides, there was a clear perspective gap between farmers and extension officers regarding the accessibility of services provided by the government. Only 20% of farmers found these services easy to access, while 75% of extension officers believed that their service was easy to access. This gap in perception suggests that farmers face various barriers such as limited service availability, poor communication, or logistical challenges. However, at extension officers' perspective, insufficient funding, low pay and lack of transportation vehicles and staff are their main challenges according to the online survey, which is in agreement with the NSDS report

(UBOS, 2022). Additionally, variations in assessment criteria, communication gaps, regional differences in infestation levels and psychological factors can also play a role (UBOS, 2022). Thus, instead of blindly improving the service quality, improving communication and understanding between these two groups would contribute more to ensuring that extension services are delivered more effectively and meet the actual needs of the farmers.

In terms of increase the knowledge of BCTB, many studies (Chong et al., 2009; Hara & Beardsley, 1979; Nanjego et al., 2024) were launched to research and understand the knowledges and drawbacks of coffee farmers on BCTB aiming to the knowing biology and status of this ambrosia bark beetle. Based on that, the cooperation between scientists, local government officers, associations and coffee farmers can be created to improve the farmers' knowledge and control this beetle at very early stages of infestation.

4.1.3 Lack of coffee organization and association

In the study, 70% of farmers reported not being members of any association, cooperative, or group, indicating a tendency to work independently rather than collaboratively within a coffee-growing community. This lack of collective action may hinder farmers' ability to access essential resources, share information, and collaborate effectively. Joining associations is one of the ways to increase information at farmer's level, while decreasing the denpendency on government funded extension services (Pertev, 2014). On the other hand, government and extension officers can also support farmers to get organized so that the information flows better between them (Babu & Gêmo, 2019). Associations and cooperatives are often crucial for agricultural development, offering benefits such as pooled resources, shared knowledge, and collective bargaining power. The low participation rate suggests a potential area for improvement, where encouraging greater involvement in such organizations could enhance productivity and address common challenges more effectively. Therefore, more functional farmer groups and associations should be created to ensure farmers get enough knowledge on their production issue and get added value for their production. Moreover, as mentioned in the survey by extension officers, building more Farmer Field School (FFS) to train farmers and provide relative education. In addition, field days or farmer group meetings can be carried out more frequently to spread knowledge and information.

4.1.4 Drought and lack of irrigation systems

In this study, water supply and irrigation systems were also highlighted to be one of the challenges, reflecting the importance of water management in coffee cultivation. In the context of global warming, drought and heat stresses are expected to occur more frequently, and have already been reported to be the two major abiotic stresses that restrict coffee production (DaMatta & Ramalho, 2006). In Uganda, a prolonged drought during 2009 and 2010 was recorded to induce a severe coffee yield reduction (Nsibirwa, 2010). Therefore, developing drought tolerant coffee cultivars might contribute to mitigating the impact of drought stress and lack of irrigation systems in local small-scale farms.

4.1.5 Other challenges

Other challenges mentioned in the survey such as road access indicate that inadequate transportation infrastructure is a substantial barrier to the development of the local coffee industry. A poor road condition slows down the product transportation, and thereby hinders the product-profit transforming process.

Regarding the coffee marketing status, the coffee products in Uganda get lower prices compared to other neighbor countries, such as Kenya and Rwanda, even though they can produce the same quality coffee bean. This is likely because the local coffee value chain has been well established yet. Coffee farmers, together with the government, face the difficulty of developing a profitable production-process-export chain due to the lack of funds. If coffee farmers can get more income from their products, they can have extra money to pay for extension service from government extension officers or private associations/groups. This can effectively improve the pest and disease management. In the future, the local government can support several large coffee farmers in one area to build their own brand. Meanwhile, monitoring and controlling the quality of coffee products, which can ensure the coffee in the world market to get more added value.

Generally, challenges related to infrastructure, such as road access and water supply, are particularly prominent, suggesting that local government intervention is necessary to address these systemic issues. Additionally, market-related challenges, such as proper returns and marketability, show considerable variability among farmers, indicating unequal access to market

opportunities and an unpredictable market demand. Farmers need to be equipped with better knowledge to deal with this complicated market variability, and thereby to secure stable and profitable market outlets for their coffee.

4.2 Repellent and Attractant traps on BCTB management (Push-pull strategy)

This study assessed the effectiveness of two treatments (verbenone and synergy of verbenone and methyl salicylate) in controlling BCTB infestation over 12 weeks. Here, the significant effect of both treatments on reducing the infestation rate at early stages aligned well with findings by previous studies (Burbano et al., 2012; Oliver & Mannion, 2001; Shankarkumar, 2022). This suggested that both the individual verbenone and synergy of verbenone and methyl salicylate were mainly effective in early stages. The larger reduction by T2 suggested a stronger effectiveness of T2 than T1 on controlling BCTB. Further, T2 also demonstrated a better consistency as compared with T1. The more variable effect of T1 may be due to Shankarkumar, (2022) and it also well reflects natural variation. This indicates a better and more stable protection against BCTB provided by the combination of verbenone and methyl salicylate than the sole verbenone. However, the effectiveness of both treatments faded away at the end of the experiment.

Based on this finding, further studies should investigate the difference of repellency mechanisms between these two treatments. Based on the superior performance of the combined repellences observed here, more combined formulas should be tested than investigation on the sole repellence. As in this study only one concentration and application rate was used. To explore the most effective treatment, more studies are needed to test out the best concentration, the most suitable repellent combination and the best timing of application.

In addition, the number of BCTBs captured by attractant traps was higher under the control compared to the verbenone and the synergy of verbenone and methyl salicylate treatments at week 2 and week 4. This indicates that both treatments effectively ‘pushed’ BCTBs away from the target trees at the early stages so that fewer could be captured. Similarly, in another study, verbenone application was also observed to reduce trap capture (Burbano et al., 2012), thereby implying the potential of suppressing pest infestation by verbenone. Our trap capture

observations, together with the earlier infestation and repellence results, all point to a clear shift in the effectiveness with the progress of the season. However, this may be attributed to natural variation in effectiveness, or other factors that this experiment has not considered. Thus, future studies need to be designed under a better controlled environment to verify these findings.

While the traps did not confirm the repellence patterns observed when applying with SPLAT-Verb, the capture was low. Although ethanol is frequently mentioned as an attractant of Xylosandrus (Burbano et al., 2012), its effectiveness may not be stable across different environments. Effective trapping is crucial for effective monitoring in IPM strategies (Guimapi et al., 2020) but even more so if deployed as 'pull' in a push-pull setting. However, using it as 'pull' may not be the ultimate purpose, as surrounding trees already form natural 'pull crops' for the beetle. It may be of interest to include oils, odors and compounds that have been shown to attract other ambrosia species. The number of BCTB captured are generally very low, and this might be ascribed to the low attractiveness of the ethanol-baited traps using locally produced alcohol 'Waragi'. This might also explain the difference of captured BCTB between the present and previous studies (Shankarkumar, 2022). Thus, the attractant in Lure-baited trap should be improved in the future study. For instance, manuka oil, phoebe oil and α-pinene have been proved to be attractive for ambrosia beetles (Hanula & Sullivan, 2008; Oliver & Mannion, 2001). Therefore, future studies should test these compound baited traps for monitoring and capturing BCTB.

4.3 Intercropping system on coffee farm

4.3.1 Shade level for coffee cultivation

In the interview and online survey, the majority of coffee farmers (80%) and extension officers (50%) reported that coffee grown under shade trees experienced more severe BCTB infestations compared to non-shaded ones, which aligned well with a previous study (Kagezi, et al., 2013a). It also confirms a study by Shankarkumar (2021) which showed that infestation rates in lower, and thus more shaded parts of the tree were higher than in the top part of coffee trees. However, some coffee farmers still grew coffee under shade trees or crops due to various reasons, such as timber, home consumption crops and income generating purpose crops. In addition, the quality of particularly robust coffee benefits from shade, especially in the aspects of growth and yield

(Piato et al., 2020). Therefore, the percentage of shade tree/crop covering the coffee is a concern for coffee farmers and extension officers.

These findings emphasize the complexity of managing BCTB in coffee farms, particularly in shaded environments. Combating pest infestation and growing high quality coffee are usually found to be opposites (Harelimana et al., 2022). While shade trees are essential for maintaining a favorable microclimate for coffee, they can also exacerbate pest issues if not carefully managed. The choice of intercropping plants plays a crucial role in balancing the benefits of shade with the need to minimize BCTB infestations. Developing a better breeding strategy aiming for pest-resistance improved coffee cultivars might be a solution.

In this study, the shade level showed a significant and positive correlation with both BCTB infestation rate and total number of infested twigs under control and T1 treatment, suggesting that higher shade level might contribute to increased infestations over time. This trend corresponds well with the general observation by local farmers that high shade level is correlated with high infestation level. However, the T2 treatment (synergy of verbenone and methyl salicylate) disrupted this trend. It also highlighted that good protective intervention such as the T2 noted here that disrupted the shade-infestation correlation may in the future allow coffee farmers to intercrop their coffee trees with more types of profitable tree species that have high shade level.

4.3.2 Intercropping crops/trees selection for mitigating BCTB infestation for coffee cultivation

The study also highlighted the importance of selecting appropriate intercropping plants to reduce BCTB infestations. Based on the survey, extension officers identified several tree species commonly found in intercropped coffee farms e.g. avocado, ‘musizi’ (*Maesopsis Eminii*), Albizia, *Ficus Natalensis*, sand olive (‘musambya’), mango, and jackfruit possessing biological characteristics that make them susceptible to BCTB infestations. These trees often have dense canopies creating a high shade level which forms a favorable environment for the pest. Ficus natalensis, Maesopsis eminii, Albizia, jackfruit and mango tree are typical host trees and have

been reported to positively contribute to correlation with BCTB infestation (Kagezi, et al., 2013).

To mitigate the risk of BCTB infestations, extension officers recommend specific intercropping plants that both support coffee growth and minimize pest issues e.g. bananas, legume crops (beans, mucuna bean, groundnuts, and soybean), elephant grass, albizia, ficus, and grevillea. For instance, banana trees provide essential shade, while legumes fix nitrogen to enrich the soil. Further, these crops can generate additional income for farmers, and the money in turn can be reinvested in farm management practices, including pest control. Thus, future research could explore a broader range of intercropping systems and their effect on BTCB infestation levels. More species can be examined to identify optimal combinations that balance coffee production with pest management. Diversifying the intercropping system also increases the overall resilience of the coffee farm which contributes to a stable yield.

Another advantage of practicing intercropping is that the intercropping trees can perform as a trap crop which further enhances the effect of repellent. Particularly in a push-pull setting, integrating well-managed intercrops will strengthen pest control function of the system. Despite the fact that the knowledge required by this type of management might still be lacking among smallholder farmers, there are already some successful examples. The push-pull maize-desmodium system has proven effective and adoptable (Erdei et al., 2024; Khan et al., 2009). It has already been used by different smallholder communities across Africa. Therefore, as long as the knowledge is delivered and the management is well monitored, utilizing intercrops in a push-pull system has good potential of controlling the BCTB.

5. Conclusion

The coffee industry is a cornerstone of Uganda's economy, accounting for a significant portion of the country's export earnings and providing livelihoods for millions of smallholder farmers. This study not only demonstrates the potential of the sole verbenone and synergy of verbenone and methyl salicylate treatments in reducing BCTB infestation but also highlights the need for a holistic approach to managing the pest. This includes better shade management, improved intercropping practices, and enhanced communication between farmers and extension officers.

By addressing these factors, it may be possible to develop more effective strategies to support Uganda coffee farmers and ensure the sustainability of their livelihoods in the face of BCTB threats. Further research is recommended to explore the mechanisms behind the repellents and to refine the approaches to BCTB management in different environmental contexts.

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Popular science summary

In Uganda, coffee is more than just a popular drink. It's a crucial part of the economy, helping to support local farmers and contributing greatly to the country's export earnings. However, Uganda’s coffee farmers face a big challenge from a tiny pest: the Black Coffee Twig Borer (BCTB). This pest infests coffee plants, leading to major losses for small farmers who already have limited resources and knowledge to manage it effectively.

To address this, we conducted a field trial in Uganda’s Kamuli district, testing a strategy called push-pull pest management. This approach uses a mix of repellents and attractants to control BCTB. Two repellent treatments were tested including one with a substance called verbenone and another combining verbenone with methyl salicylate. The results were promising: early on, both treatments reduced BCTB infestations and prevented new entry holes in the coffee branches. The combination of verbenone and methyl salicylate was proved especially effective.

Interestingly, the trials also revealed that coffee plants growing under more shade had higher BCTB infestation rates, confirming observations made by local farmers. This trend was less pronounced in areas treated with the combined repellents, suggesting that the repellents may have masked the impact of shade.

The study highlighted that many farmers knew about BCTB but struggled to identify it accurately or manage it effectively. While they used some methods like burning infested plant material, this was labor-intensive and hard to sustain. The trial also pointed out communication gaps between farmers and agricultural extension officers, limiting the support available to farmers.

This research offers new insights into pest control methods, pointing toward the need for more effective pest management support for Ugandan coffee farmers. Improved extension services and deeper research into repellents could greatly help stabilize coffee farming in Uganda, benefiting both the local economy and farmers' livelihoods.

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Appendix 1: Survey on knowledge, management and improvement of BCTB infestation for coffee plantation

Respondents of the Online Survey

Respondent 1	Bagabo Michael - Kamuli District local Government
Respondent 2	Okello Patrick - MAAIF
Respondent 3	MBEIZA MOUREEN - Iowa state university- Uganda Program kamuli district
Respondent 4	Nakintu Doreen - Namasagali, Kamuli
Respondent 5	Balibuzani Ronald - Bugulumbya s/c
Respondent 6	Kipwapwa Emmanuel - Kamuli DLG Nawanyago T/C

Respondent 7	Charles Kasulawa - Mbulamuti subcounty
Respondent 8	Kategere Charles - Kamuli district Namwendwa subcounty
Respondent 9	Kipwapwa Emmanuel - Kamuli Nawanyago town council
Respondent 10	Baguma Michael - Uganda coffee development Authority - Kamuli & Buyende districts
Respondent 11	Musenja Grace - Kamuli district
Respondent 12	Charles Naaya - Kamuli District local Government
Respondent 13	MUGABI ASHIRAFU - MAAIF
Respondent 14	Lukwata Martin - Roy KagoyeIowa state university- Uganda Program kamuli district
Respondent 15	Banige David - Namasagali, Kamuli
Respondent 16	Lutwama Dennis - Bugulumbya s/c

1 What's your work position?

Respondent 1	extension officer
Respondent 2	Agricultural Inspector
Respondent 3	extension officer
Respondent 4	extension officer
Respondent 5	extension officer
Respondent 6	extension officer
Respondent 7	extension officer
Respondent 8	extension officer
Respondent 9	extension officer
Respondent 10	extension officer
Respondent 11	extension officer
Respondent 12	extension officer
Respondent 13	extension officer
Respondent 14	Youth Entrepreneurship Specialist
Respondent 15	extension officer
Respondent 16	School gardening and Service-Learning specialists

2 What's your role as an agricultural officer/scientist?

Respondent 1	Disseminate information and train farmers on good agronomic practices of crop sector in the district
Respondent 2	Inspection and certification
Respondent 3	Identifying and disseminating innovations to improve soil and crop productivity
Respondent 4	1.Trainings on different crop agronomy, 2.Awareness creation on pests and diseases 3. Post harvest measures and technologies 4. Quality assurance

Respondent 5	To plan, organize, coordinate, manage and monitor the agricultural activities and to ensure adequate and high quality services for increased agricultural production.
Respondent 6	To train farmers on good agronomic practices To train farmers on post harvest handling,farming as a business such for market, awareness on pests and diseases
Respondent 7	Train farmers on modern agricultural practices and collect agriculture statistics
Respondent 8	To plan, organize, coordinate, manage and monitor the crop sub-sector programmes and activities of the district and ensure adequate and high -quality services for increased production of crops for food and nutrition security, incomes and exports.
Respondent 9	To train farmers on GAPs To train farmers on post harvest handling To train farmers on farming as a business
Respondent 10	Dissemination of agricultural technologies and innovations through trainings and farm visits to coffee farmers
Respondent 11	Training and guiding farmers on crop production and productivity
Respondent 12	Training farmers in modern farming methods.
Respondent 13	PROVISION OF ADVISORY SERVICES TO FARMERS ESPECIALLY TO THE PROBLEMS THEY FACE DAY TO DAY AT THEIR FARMS/ GARDENS.
Respondent 14	1. Coordinating ISU-UP Youth Entrepreneurship Program initiatives, activities and communications 2. Building capacity of youth to initiate and manage agricultural projects which enhance their skills, incomes and sustainable livelihoods
Respondent 15	To disseminate appropriate agricultural information to the farmers
Respondent 16	training school going children basic knowledge in crop production management

3 What is the most important crop in your area?(production-wise)

Respondent 1	Coffee
Respondent 2	Maize
Respondent 3	Maize for annual crops, then coffee ad cocoa for perennial trees
Respondent 4	Maize
Respondent 5	Coffee
Respondent 6	maize
Respondent 7	Maize
Respondent 8	Maize
Respondent 9	maize
Respondent 10	Coffee
Respondent 11	Maize
Respondent 12	Maize
Respondent 13	COFFEE
Respondent 14	Maize
Respondent 15	Maize
Respondent 16	Maize

4 What is the most important crop in your area?(revenue-wise)

Respondent 1	Coffee
Respondent 2	Coffee
Respondent 3	coffee
Respondent 4	Coffee
Respondent 5	Coffee
Respondent 6	coffee
Respondent 7	Coffee
Respondent 8	Coffee
Respondent 9	coffee
Respondent 10	Coffee
Respondent 11	Coffee
Respondent 12	Coffee
Respondent 13	COFFEE
Respondent 14	Tomatoes
Respondent 15	Coffee
Respondent 16	Sugar Cane

5 Number of coffee farms in your district/area?

Respondent 1	150 acres on estimate in Balawoli sub county
Respondent 2	Every home stead grows coffee
Respondent 3	Approx. 660 farms
Respondent 4	250
Respondent 5	Over 20,000
Respondent 6	250
Respondent 7	2300
Respondent 8	75
Respondent 9	150
Respondent 10	70000
Respondent 11	250 farmers in Kagumba Sub county
Respondent 12	12300
Respondent 13	241 ACRES
Respondent 14	Not sure
Respondent 15	33
Respondent 16	Appx 65

6 The average size of coffee farms? (in acres)

Respondent 1	3 acres
Respondent 2	1-2.5 acres
Respondent 3	Each farm as average of 0.8 acres
Respondent 4	540
Respondent 5	1 acre
Respondent 6	150
Respondent 7	1
Respondent 8	1 acre
Respondent 9	100
Respondent 10	0.5-1 acre
Respondent 11	1
Respondent 12	1 acre
Respondent 13	2 ACRES
Respondent 14	0.5 acres
Respondent 15	1.5 acres
Respondent 16	0,45

7 Type of coffee grown?

Respondent 1	Robusta
Respondent 2	Arabica
Respondent 3	Robusta
Respondent 4	Robusta
Respondent 5	Robusta
Respondent 6	Robusta
Respondent 7	Robusta
Respondent 8	Robusta
Respondent 9	Robusta
Respondent 10	Robusta
Respondent 11	Robusta
Respondent 12	Robusta
Respondent 13	Arabica
Respondent 14	Robusta
Respondent 15	Robusta
Respondent 16	Robusta

8 How many farmers do you give advice to/ come under your supervision?

Respondent 1	1500 farmers in a quarter
Respondent 2	500
Respondent 3	I work with approximately 3000 farmers per year, but advise them based on the crop enterprise. For coffee, they are approximately 660 farmers
Respondent 4	1200
Respondent 5	Above 10000
Respondent 6	200
Respondent 7	5000 households
Respondent 8	76
Respondent 9	350
Respondent 10	30000
Respondent 11	35000 farmers
Respondent 12	5000
Respondent 13	8734 FARMERS.
Respondent 14	approximately 1000
Respondent 15	50
Respondent 16	appx 15

9 Is it easy for the farmers to access the government extension services/information from extension workers?

Respondent 1	easy
Respondent 2	easy
Respondent 3	easy
Respondent 4	easy
Respondent 5	easy
Respondent 6	easy
Respondent 7	easy
Respondent 8	difficult
Respondent 9	easy
Respondent 10	easy
Respondent 11	easy
Respondent 12	easy
Respondent 13	easy
Respondent 14	difficult
Respondent 15	difficult
Respondent 16	difficult

10 In your opinion, what needs to be done for improvement from their side?

Respondent 1	Improvement on disease resistant varieties Improvement on post harvest handling procedures
Respondent 2	Paying more attention in monitoring their coffee fields
Respondent 3	Adopt coffee stumping and growing of disease resistant varieties released by research institute(NACORI)
Respondent 4	Timely planting, proper spacing, attending trainings
Respondent 5	Put into practice what has been trained & do it persistently
Respondent 6	The farmers should adopt new technologies
Respondent 7	Recruit extension workers at sub-county level
Respondent 8	They should form groups
Respondent 9	having more FFS Field days
Respondent 10	Farmers need to go digital in accessing extension services e.g use of WhatsApp, zoom, etc
Respondent 11	Continuous trainings in mindset change , demo sites established , farmer organizations empowered
Respondent 12	More support with inputs for demonstration gardens setup and managed by extension officers.
Respondent 13	PRACTICE OF CULTURAL PRACTICES TO MANAGE PESTS AND DISEASES.
Respondent 14	Improve facilitation of government extension workers so as they increase their coverage
Respondent 15	Minimum supervision of the extension workers to ensure they provide good service delivery
Respondent 16	Increase on the number of extension services to match the increasing population

11 What are the often heard questions/complaints, etc. with regards to coffee? (it could be more than one)

Respondent 1	Pests and diseases identification and pesticides used to control especially coffee twiger borer Good agronomic practices
Respondent 2	How to deal with coffee twig borer
Respondent 3	reduced production due to drying of coffee trees, twigs and berries
Respondent 4	Pests and diseases Dry spells Low fertility which leads to production of small beans
Respondent 5	No hard questions experienced on coffee
Respondent 6	The infestation of twig borers is too high price fluctuation
Respondent 7	1. Black coffee twig borer, 2) Red blister disease, black ants
Respondent 8	How to control twig borers and where to get quality seedlings.
Respondent 9	Costs of agro chemicals Price fluctuation
Respondent 10	Black coffee twig borer, Red blister disease
Respondent 11	How to manage coffee twig borer and other pests How to manage red blister disease Why dries during drought
Respondent 12	Diseases such Coffee Wilt Disease and pests such as Black coffee twig borer Long gestation period
Respondent 13	1. WHAT IS THE LIFESPAN OF A COFFEE PLANT

	2. IS COFFEE TWIG BORER A PEST OR DISEASE. 3. WHAT ARE THE PRODUCTS GOT FROM COFFEE.
Respondent 14	1. Coffee Wilting 2. Drought
Respondent 15	How to control of Black Coffee Twig Borer, How to increase coffee yields per unit area
Respondent 16	How to control Black coffee twig borer

12 How often do you visit each farmer's field for advice/ supervision?

Respondent 1	Once in a week
Respondent 2	twice a week
Respondent 3	once a months, or when on call.
Respondent 4	Quarterly
Respondent 5	
Respondent 6	twice a week
Respondent 7	Averagely three times in a quarter of a year
Respondent 8	Once every month
Respondent 9	twice a week
Respondent 10	Monthly
Respondent 11	Monthly
Respondent 12	Once a month
Respondent 13	AT LEAST ONCE IN EVERY MONTH.
Respondent 14	Provide support to farmers periodically as need arises. Work with 70 new farmers every quarter.
Respondent 15	Twice a month
Respondent 16	Once in two Months

13 What needs to be done to improve the extension delivery from your side?

Respondent 1	More capacity building of extension officers
Respondent 2	Facilitation in terms of movement to the field (motorbikes)
Respondent 3	Add more extension staff. we are still fewer
Respondent 4	Provision of enough fuel on time Provision of inputs e.g fertilizers to those active farmers
Respondent 5	Reduce the extension/farmer ratio. At Least add another extension staff I the sub county
Respondent 6	Forming farmer field school. Field days.
Respondent 7	Increase fuel for extension workers and increase monitoring
Respondent 8	Increase the number of extension staff.
Respondent 9	forming more farmer groups forming more FFS and field days

Respondent 10	Not as such however government provides me enough fuel to offer extension services therefore Farmers have to show interest and request for my services
Respondent 11	Timely acquisition of fuel and facilitation Enough demo materials to be availed Establishment of well facilitated farm field schools
Respondent 12	Supporting establishment of demo gardens to be directly managed and supervised by Extension officers.
Respondent 13	PROVISION OF MEANS OF TRANSPORT AND MORE FUEL FOR TRANSPORTATION TO COVER MORE FARMERS.
Respondent 14	Technological improvements to facilitate remote extension methods for farmers
Respondent 15	Increasing the number of extension workers
Respondent 16	The government should recruit extension assistants at parish level

14 What are the common pests and diseases of coffee in terms of incidence/ spread?

Respondent 1	Coffee twig borer Red blister disease Coffee wilt disease
Respondent 2	Coffee twig borer and coffee rust
Respondent 3	Black coffee twig borer is the most occurrent, leaf miner and mealy burg, then some ants and caterpillars
Respondent 4	Coffee twig borer Coffee blister disease
Respondent 5	Black coffee twig borer(BCTB) & coffee wilt
Respondent 6	coffee twig borer
Respondent 7	Twig borer, leaf miners, skeletonizer
Respondent 8	Black coffee twig borer. Coffee wilt disease
Respondent 9	twig borers
Respondent 10	Black coffee twig borer, biting ants, mealy bugs, scales, tailed caterpillar etc, Red blister disease, root rot, coffee wilt, leaf rust etc
Respondent 11	Pests include. Black coffee twig borer , leaf miners , termites and Diseases
Respondent 12	Pests: Black Coffee Twig Borers, Coffee Berry Borer respectively. Diseases: Coffee Wilt Disease, Coffee Berry Disease, Red coffee blister, respectively
Respondent 13	1. COFFEE TWIG BORER. 2. COFFEE LEAF RUST 3. COFFEE BERRY DISEASE. 4. MEALYBUGS COFFEE LEAF MINER
Respondent 14	coffee twig borer
Respondent 15	Black coffee Twig Borer, Coffee wilt disease
Respondent 16	Coffee twig borer- coffee berry disease

15 What are the common pests and diseases of coffee in terms of economic importance?

Respondent 1	Coffee twig borer

	Red blister disease Coffee wilt disease
Respondent 2	Coffee twig borer
Respondent 3	black coffee twig borer
Respondent 4	Coffee twig borer Coffee blister disease
Respondent 5	BCTB, Coffee wilt & red blister,
Respondent 6	leaf rust
Respondent 7	Red Blister disease, root rots, fusarium wilt
Respondent 8	Black coffee twig borer
Respondent 9	leaf rust
Respondent 10	Black coffee twig borer, tailed caterpillar, White mealy bugs, and Red blister disease, root rot
Respondent 11	Pests: Black coffee twig borers Disease: Red blister disease
Respondent 12	Pests: Coffee Twig Borer Diseases: Coffee Wilt Disease
Respondent 13	1. COFFEE TWIG BORER 2. COFFEE LEAF MINER 3. MEALYBUGS 4 COFFEE BERRY BORER.
Respondent 14	coffee wilt disease
Respondent 15	Coffee berry borer, Coffee mealybugs, coffee leaf rust
Respondent 16	Coffee twig borer

16 Are there any districts/ regions that are more severely affected?

Respondent 1	Yes
Respondent 2	Yes
Respondent 3	kamuli and luuka district
Respondent 4	Yes
Respondent 5	Am not aware of this
Respondent 6	Kamuli, kaliro,luuka
Respondent 7	Yes, Kamuli is severely affected
Respondent 8	Not sure
Respondent 9	kamuli ,kaliro luuka
Respondent 10	Yes, All the above are affecting the entire country
Respondent 11	Yes
Respondent 12	Yes, Kamuli has a higher infestation by Black Coffee Twig Borer
Respondent 13	SPREAD IS ALMOST THE SAME IN ALL THE PARTS OF THE COUNTY.
Respondent 14	Masaka
Respondent 15	Kamuli District/ Busoga region

Respondent 16	Yes

17 What is your perception of the BCTB?

Respondent 1	Can lead to serious losses to a farmer
Respondent 2	Very destructive
Respondent 3	severely cause economic loss in terms of yield since it makes twigs and berries dry.
Respondent 4	
Respondent 5	It's a serious economic coffee pest, but if farmers can work together as a village or parish and they agree to put into practice the various control measures then it can be managed
Respondent 6	
Respondent 7	It is the number one coffee pest
Respondent 8	It's a serious pest
Respondent 9	it should be handled with care
Respondent 10	It is a monster in Uganda that needs to be given maximum attention because it is leading to a 2 kg loss of red cherries per tree per year
Respondent 11	It is a serious pest of coffee which can cause economic loss
Respondent 12	An economically devastating pest of coffee especially Robusta coffee.
Respondent 13	ITS SPREAD IS HIGH ON THE FARMERS PLANTATIONS BUT ITS EASY TO CONTROL ESPECIALLY BY THE USE OF IPM APPROACH.
Respondent 14	It is a very dangerous pest that farmers don't understand
Respondent 15	BCTB is currently a major pest of coffee in Uganda which has caused significant economic loss among coffee farmers. BCTB is a highly invasive and damaging pest that spreads far and wide over a short period of time.
Respondent 16	Training farmers on how to control BCTB/ Develop lure to attract the Borer

18 Would you say BCTB is the major pest for coffee plant?

Respondent 1	yes
Respondent 2	yes
Respondent 3	yes
Respondent 4	yes
Respondent 5	yes
Respondent 6	yes
Respondent 7	yes
Respondent 8	yes
Respondent 9	yes
Respondent 10	yes
Respondent 11	yes
Respondent 12	yes
Respondent 13	yes

Respondent 14	yes
Respondent 15	yes
Respondent 16	yes

19 If yes, could you elaborate on this? (for eg. possible reasons, yield/ quantity loss in %, etc.)

Respondent 1	0,4
Respondent 2	The losses caused to farmers is big depending on the management practices by farmers
Respondent 3	its dries out the berries and twigs and if not handled earlier, kills entire tree, causing approx. 60% of loss made in production
Respondent 4	Its control needs an IPM approach yet most farmers use chemical which alone cannot control the pest hence lowering the yields
Respondent 5	It can cause UpTo 75 percentage loss
Respondent 6	0,5
Respondent 7	It destroys the twigs that are supposed to bear th berries, 2) The cultural control that emphasize removal of twigs leave the tree without points of growth
Respondent 8	50% loss
Respondent 9	0,5
Respondent 10	2 kg loss of red cherries per tree per year
Respondent 11	It is hard to manage as its Pesticide is expensive Loss 60%
Respondent 12	Attacks coffee tree twigs, burrows into them leading to total drying/death of the twigs hence reduced yields.
Respondent 13	35% LOSS.
Respondent 14	Most Farmers don't know how to identify and control it. Farmers lose over 60% of plants in extreme cases
Respondent 15	BCTB bores into the berry bearing primary branches (twigs) causing them to wilt and eventually dies after a few weeks. A farmer can lose up to 50% of the coffee yield if they do not manage BCTB on the farm.
Respondent 16	In most cases it causes total loss since most of the plants dry with the coffee at early stages . It causes 100% yield loss

20 If not, which other pests are more important and the possible reasons behind this?

Respondent 1	Not applicable
Respondent 2	
Respondent 3	mainly coffee twig is most important.
Respondent 4	
Respondent 5	N/A
Respondent 6	yes
Respondent 7	BCTB is the most important now followed by dodder
Respondent 8	
Respondent 9	
Respondent 10	

Respondent 11	
Respondent 12	
Respondent 13	ITS THE MOST ECONOMICALLY IMPORTANT PEST IN COFFEE.
Respondent 14	N/A
Respondent 15	
Respondent 16	

21 What are the symptoms of BCTB/ how do you find the BCTB attack?

Respondent 1	Holes in the coffee branches
Respondent 2	Drying off the branches
Respondent 3	leaves start becoming yellow, Death of plant tissues from point of attacks outside leaves died. drying of twigs and berries from point of attack (twigs) towards the stem.
Respondent 4	Dried premature twigs Holes on the twigs
Respondent 5	Bores into primary branches & main stems affected branches die off and become black
Respondent 6	Drying of twigs premature berries abortion of berries Drying of leaves half way
Respondent 7	Pin holes in twigs, drying of twigs
Respondent 8	Drying of the branches Falling of the prematurely berries
Respondent 9	drying of twigs premature berries drying of leaves half way
Respondent 10	Wilting and drying of twigs
Respondent 11	Wilting and Drying fo twigs Tiny pin holes observed at under side of the twigs . Powdery substance seen at the pin hole When the twig is broken small black or eggs of BCTB are observed
Respondent 12	Dieback of coffee tree twigs, especially tender ones. Grubs can be seen when an affected twig is dissected through.
Respondent 13	1. SAP OOZING FROM SMALL HOLES IN BRANCHES OR TREE TRUNKS. 2. BARK THAT APPEARS SWOLLEN, POSSIBLY CRACKING HENCE CAUSING SMALL AREAS YO BREAK OFF. 3. DISCOLOURED, UNDERSIZED, LEAVES ON THE UPPER PART OF THE TREE AND DYING BRANCHES.
Respondent 14	Wilting of coffee branches
Respondent 15	Wilting of twigs and branches, Holes in twigs, Blackening of the stem and leaves from the entrance hole towards the tip of the branch.
Respondent 16	Wilting and drying of the twigs, leaves and primary branches

22 When did you come to know about BCTB and its spread in Uganda?

Respondent 1	10 years back

Respondent 2	Early 2000
Respondent 3	2016
Respondent 4	2015
Respondent 5	2014
Respondent 6	Training by UCDA Training at the district Field days
Respondent 7	In 2018 during the trainings under the TICS project in Kamuli district
Respondent 8	8years back
Respondent 9	By UCDA By trainings at the districts Over the radio
Respondent 10	2019
Respondent 11	I knew it from University (Makerere) in 2011
Respondent 12	5 years ago
Respondent 13	2004
Respondent 14	2019
Respondent 15	2019
Respondent 16	2015

23 How does the BCTB spread from region to region?

Respondent 1	Through plant contacts
Respondent 2	Unclean planting materials
Respondent 3	Through tools used for pruning, insects fly from plant to plant over long distance. use of diseased planting materials. host plants like musambya and musizi
Respondent 4	Flying from one field to another
Respondent 5	
Respondent 6	Transporting deceased planting materials Through collecting twigs as firewood
Respondent 7	Adults move from branch to branch. Also wood collectors disperse them, rain
Respondent 8	Through seedling Through trading From one tree to another
Respondent 9	transporting infested planting materials
Respondent 10	By flying following wind direction, through BCTB host trees like Musizi
Respondent 11	It is itself through flying from one region to another
Respondent 12	Transportation of coffee seedlings for planting, Movement of adult twig borers in air.
Respondent 13	THE SMALL BLACK INSECT FLIES/ MOVES FROM ONE PLANT TO ANOTHER AND THEN BORES INTO THE PLANT.
Respondent 14	Movement of infested plants from region to region
Respondent 15	The BCTB can fly over a long distance from one region to another which stimulates its spread. Movement

	of affected coffee planting materials from one region to another
Respondent 16	The insects move from one tree to another/ from one region to another region

24 Looking at the BCTB problem, how is the level of infestation now compared to previous years?

Respondent 1	Increased
Respondent 2	increased
Respondent 3	increased
Respondent 4	reduced
Respondent 5	reduced
Respondent 6	very much reduced
Respondent 7	increased
Respondent 8	increased
Respondent 9	very much increased
Respondent 10	almost the same
Respondent 11	reduced
Respondent 12	reduced
Respondent 13	almost the same
Respondent 14	almost the same
Respondent 15	very much increased
Respondent 16	very much increased

25 And why? (follow the question 24)

Respondent 1	Low awareness
Respondent 2	There's no proper measures in place
Respondent 3	planting non- resistant materials, less time given to inspect the gardens, increased planting of musizi
Respondent 4	Level infestation is low, even the yield increased abit in my area
Respondent 5	A lot of public awareness doe on BCTB & availability of pesticides on open market
Respondent 6	The adoptation to practices which can reduce the infestation is still very low by farmers
Respondent 7	Farmers failing to adopt the recommended practices
Respondent 8	Almost on every farm it's more pronounced
Respondent 9	farmer's adoptabilty to new technologies is too low
Respondent 10	They heavily affect much in dry seasons compared to rainy seasons
Respondent 11	By Sensitization of farmers on its management
Respondent 12	Awareness creation on BCTB is much higher than before.
Respondent 13	BECAUSE THE CONTROL MEASURES ARE NOT CONSISTENTLY IMPLEMENTED BU FARMERS.
Respondent 14	Farmer knowledge and perceptions have not changed

Respondent 15	Most farmers are less knowledgeable about the management strategies of BCTB.
Respondent 16	Less knowldege on control of the BCTB

26 Are you expecting any change in this trend in the near future?

Respondent 1	yes
Respondent 2	yes
Respondent 3	yes
Respondent 4	yes
Respondent 5	yes
Respondent 6	yes
Respondent 7	no
Respondent 8	yes
Respondent 9	yes
Respondent 10	yes
Respondent 11	yes
Respondent 12	no
Respondent 13	yes
Respondent 14	yes
Respondent 15	yes
Respondent 16	no

27 If yes, could you describe on what you are expecting?

Respondent 1	Decrease
Respondent 2	A reduction in the spread
Respondent 3	Tree nurseries with disease resistant varieties have been established in each district, and model farmers so farmers will be able to access knowledge and clean planting materials
Respondent 4	To reduce thoroughly
Respondent 5	If the coffee market price increases this will force more farmers to observe BCTB control measures such that they are able get good harvests and get more income.
Respondent 6	More trainings on the infestation cauesed by the pest and mind set change
Respondent 7	0
Respondent 8	If only resistant seedlings are produced
Respondent 9	yes if farmers mind set change positively to the training by agriculture officers
Respondent 10	I expect it to lower, proven recommended measures have been disseminated to farmers and most especially on removal of alternate host trees for BCTB from coffee shambas and planting recommended shade trees like ficus natalensis, ficus mucuso, ficus ovata and albizia coriaria
Respondent 11	Farmers are getting knowledge on it's management and reducing host plants from their gardens
Respondent 12	0
Respondent 13	USE OF IPM TO CONTROL THE PEST.

Respondent 14	With the continued research into control of the BCTB, we expect dissemination of new knowledge to help farmers
Respondent 15	Am expecting a change in future because more research is being carried out on the management of BCTB, for example some tree species are being recommended to be planted in coffee farms other than other trees like "musizi and musambya" which are alternate host trees of the BCTB
Respondent 16	

28 What time of the year/ season (month) do you find its incidence more and why?

Respondent 1	During hot days
Respondent 2	Its through out the production cycle
Respondent 3	March to june . that is period of coffee flowering and fruiting.
Respondent 4	The incidence is high during dry season, due to increased temperatures, the eggs hatch much faster
Respondent 5	January to march, it is because temperatures are high/ dry season so they look for conducive environment and harbors in the coffee shrubs
Respondent 6	December, January, February
Respondent 7	June - August. This is because the dry conditions enable rapid spread
Respondent 8	Almost all the year round
Respondent 9	December, january and february
Respondent 10	Dry seasons, they attack trees when are stressed and after the trees producing alcoholic compounds that attracts them
Respondent 11	Dry season December to March Because it favors multiplication and crops are water stressed
Respondent 12	Dry season. Coffee Plant immunity is low.
Respondent 13	AUGUST AND SEPTEMBER, JANUARY, FEBRUARY, MARCH APRIL. BECAUSE AT THIS TIME, THE FARMERS HAVE DISTURBED THE PLANT IN THE COURSE OF HARVESTING. AND NOW THE PLANT IS EVEN WEAKER.
Respondent 14	Dry season
Respondent 15	During dry season January, February, this is because BCTB tend to thrive more in warmer temperatures than cooler temperatures.
Respondent 16	dry season (December - Early March)

29 Which stage of the BCTB causes damage on the coffee trees?

Respondent 1	Adult insect
Respondent 2	Adult
Respondent 3	adults
Respondent 4	Adult stage
Respondent 5	Larvae
Respondent 6	adult stage
Respondent 7	Larval
Respondent 8	Not sure
Respondent 9	at flowering stage

Respondent 10	Adult
Respondent 11	Larvae stage as it clogs inner lining of the twig by the Ambrosia fungi . This blocks translocation of water and food
Respondent 12	Larva/grub
Respondent 13	LARVAE STAGE OF THE LIFE CYCLE.
Respondent 14	larvae
Respondent 15	Larvae stage. The larvae of the BCTB cause damage on the coffee trees by tunneling into the twigs, leaving pin sized holes.
Respondent 16	

30 How is the government's level of attention to the impact of the BCTB? (Out of 10)

Respondent 1	3
Respondent 2	8
Respondent 3	5
Respondent 4	4
Respondent 5	9
Respondent 6	5
Respondent 7	6
Respondent 8	5
Respondent 9	5
Respondent 10	9
Respondent 11	6
Respondent 12	4
Respondent 13	7
Respondent 14	3
Respondent 15	5
Respondent 16	2

31 Are there any government directives regarding BCTB control?

Respondent 1	No
Respondent 2	yes
Respondent 3	yes
Respondent 4	No
Respondent 5	yes
Respondent 6	No
Respondent 7	yes
Respondent 8	yes
Respondent 9	No

Respondent 10	yes
Respondent 11	No
Respondent 12	No
Respondent 13	yes
Respondent 14	yes
Respondent 15	yes
Respondent 16	No

32 If yes, could you tell more?

Respondent 1	Not applicable
Respondent 2	Supply of resistant varieties and the use of IPM
Respondent 3	planting clean materials from certified nurseries, inspect gardens and cut and burn infected trees
Respondent 4	
Respondent 5	Production department has a budget line for public awareness meetings on major crop pests and diseases
Respondent 6	not yet
Respondent 7	Training the prioritises coffee, avoiding infested gardens
Respondent 8	Uganda coffee development authority is trying to ensure that quality coffee seedlings are produced
Respondent 9	n/a
Respondent 10	Pruning and burning affected twigs, desuckering, removal of alternate host trees for BCTB like mangoes, jackfruit, ovacado, Musizi, etc
Respondent 11	
Respondent 12	
Respondent 13	1. USE PEST FREE PLANTING MATERIALS FROM CERTIFIED COFFEE NURSERIES. 2. INSPECT YOUR FIELD REGULARLY TO IDENTIFY ANY INFESTATION.
Respondent 14	Government has literature on the pest and its control at different district agriculture offices
Respondent 15	The government through National Coffee Research Institute (NACORI) is highly effective in fighting the BCTB by encouraging the farmers to use pest free planting materials from Uganda Coffee Development Authority (UCDA) certified nurseries only. Also the government through media such as radios and Televisions is encouraging farmers to regularly inspect their coffee farms for any infestation, as soon as the pest is sighted, cut, chop and burn the affected plants parts to prevent the spread.
Respondent 16	

33 What intergrated pest managemnet(IPM) practices do you suggest to the farmers against the coffee pests (BCTB inclusive)?

Respondent 1	Field cleaning of weeds Proper pruning Removal of affected branches and burn Use of recommended pesticides
Respondent 2	Field hygiene, pruning, resistant varieties and use of conventional pesticides
Respondent 3	plant albizia with coffee. avoid planting musambya and musizi being disease host plants
Respondent 4	Removing affected twigs from the plant and those on the ground, plus dried leaves, burn them Then spray using Imidacloprid at an interval of two weeks, 4mls/ ltr

Respondent 5	Monitor the field for any infestation Clean weeding to burry pests on the ground Trim off & burn affected branches Reduce excessive shade Spray with IMAX/Imida pesticides for heavily affected plantations
Respondent 6	A void planting host trees like musizi
Respondent 7	1. Reduce shade, remove destroyed seed, avoid moving dead coffee wood in coffee garden, use striker or imodoclopid
Respondent 8	Not sure
Respondent 9	planting shade trees like ficus tree and cariandra
Respondent 10	Pruning and burning affected twigs, desuckering, removal of alternate host trees for BCTB, proper feeding of coffee trees
Respondent 11	Removing host plants Planting recommended shade trees Field sanitation Use of chemicals (Imidacloprid)as the last option.
Respondent 12	Pruning affected twigs and burn them in situ
Respondent 13	1. CULTURAL CONTROL METHODS. 2. PHYSICAL METHODS 3. USE OF TRAPS/ BAITS. 4.CHEMICAL METHODS.
Respondent 14	use of insect traps
Respondent 15	Apply organic manure or fertilizer to promote good plant health and vigor, Promote good soil and water conservation practices, Regularly monitor for the symptoms of BCTB.
Respondent 16	Use of organic manures and use of shade trees

34 Are there any management practices control BCTB specially?

Respondent 1	yes
Respondent 2	no
Respondent 3	yes
Respondent 4	yes
Respondent 5	yes
Respondent 6	yes
Respondent 7	yes
Respondent 8	yes
Respondent 9	yes
Respondent 10	yes
Respondent 11	yes
Respondent 12	not sure
Respondent 13	yes
Respondent 14	yes
Respondent 15	yes

Respondent 16	not sure

35 if yes, Could you mention some BCTB management practices that control BCTB specially?

Respondent 1	Use of recommended pesticides Removal of affected branches and burn
Respondent 2	
Respondent 3	planting alizia, inspecting gardens regularly, planting clean materials from certified nurseries
Respondent 4	Planting the recommended shade trees e g Ficus sp which don't attract the pest
Respondent 5	Clean wedding to bury any pests on the ground Reduce on excessive shade Regular desuckering
Respondent 6	pruning of the coffee plantation. removing and burning of infested twigs. spraying use imidacloprid 120mls/20ltrs
Respondent 7	Avoid dragging wood through coffee gardens, reduce on number shade trees
Respondent 8	Removing dry branches. Removing shades
Respondent 9	burning infested twigs
Respondent 10	Pruning and burning of affected twigs, desuckering, removal of alternate host trees for BCTB, use of traps
Respondent 11	Pruning infested twigs Field sanitation Use of recommended shade trees Chemical control - Imidacloprid
Respondent 12	
Respondent 13	1. PROMPT REMOVAL OF INFESTED BRANCHES, DESTROY THEM BY EITHER COMPOSTING, BURYING OR BURNING. 2. MAINTAINING HEALTH PLANTS BY PROVIDING COFFEE TREES WITH CONSISTENT AND ENOUGH FERTILIZERS.
Respondent 14	use of insect traps
Respondent 15	Avoid using tree species such as "Musizi and Musambya" because these are alternate host trees of BCTB. Inspection of the field regularly to identify any infestation, Using traps;- the trap is composed of a transparent plastic bottle, a smaller pharmaceutical bottle, ethanol and a wire or string.
Respondent 16	

36 What is the recommended spacing in coffee gardens? (Between coffee)

Respondent 1	10*10 feet robust
Respondent 2	3*3m
Respondent 3	10ft by 10ft
Respondent 4	10 by 10ft for robusta, 8 bt 8ft for arabica
Respondent 5	10ft x10fr
Respondent 6	3m by3m
Respondent 7	3x3 M
Respondent 8	10by 10feet

Respondent 9	3mby3m
Respondent 10	10ft*10ft or 3M*3M
Respondent 11	10ft x10ft
Respondent 12	3m by 3m (10ft by 10ft)
Respondent 13	10ft BY 10ft.
Respondent 14	9ft*9ft
Respondent 15	3M by 3M (10ft by 10ft)
Respondent 16	3m by 3m

37 What is the recommended spacing in coffee gardens? (Between coffee and intercrop)

Respondent 1	10*10 feet
Respondent 2	No clear standard measurements used
Respondent 3	15ft by 15ft
Respondent 4	0
Respondent 5	0
Respondent 6	3m by 3m if the coffee is the main crop
Respondent 7	X20 in coffee banana
Respondent 8	20 by 20 feet
Respondent 9	6mby6m
Respondent 10	5ft apart from coffee to banana
Respondent 11	5ft x 20ft
Respondent 12	Depends on the intercrop but intercrop should not be under coffee crop canopy.
Respondent 13	2m APART WITH PLANTS, 1.5m WITH IN THE ROW.
Respondent 14	4ft*4ft
Respondent 15	Between 3.5 to 4.5m. The spacing must be increased from 3m to 3.5m-4.5m to allow more light penetration to reach the perennial intercrop when they have established.
Respondent 16	3m by 4m

38 What is the recommended spacing in coffee gardens? (Between the intercrop)

Respondent 1	10*10 feet
Respondent 2	0
Respondent 3	15ft by 15ft
Respondent 4	20 by 20 ft
Respondent 5	Depends on the type of inter crop eg for bananas it is 20ftx 20ft
Respondent 6	6m by 6m
Respondent 7	20*10
Respondent 8	Not sure

Respondent 9	20ft by 20ft
Respondent 10	20ft*20ft for banana intercrop
Respondent 11	Intercrop 20ftx 20ft
Respondent 12	
Respondent 13	20ft BY 20ft.
Respondent 14	12ft*12ft
Respondent 15	1m by 1m
Respondent 16	3m by 3m

39 What is the recommended spacing in coffee gardens? (Between coffee and shade trees)

Respondent 1	10*10 feet
Respondent 2	4*2m
Respondent 3	15-20m by 15-20 m depending on variety
Respondent 4	20 by 20 ft
Respondent 5	0
Respondent 6	in a coffee a garden shade trees should be at a spacing 30 by 30 ft and coffee 3m by3m
Respondent 7	20*20
Respondent 8	Not sure
Respondent 9	30ft by 30ft
Respondent 10	5ft apart from coffee to shade trees and the spacing from one shade tree to another should be 20M
Respondent 11	20mx20m
Respondent 12	Spacing of shade trees in a coffee field is 35m apart.
Respondent 13	20m BETWEEN EACH TREE.
Respondent 14	12ft*12ft
Respondent 15	20m by 20m
Respondent 16	10 m by 15m

40 Is spacing important? why?(you can mention more than one)

Respondent 1	Yes Increased yields
Respondent 2	For better yields and for control of pests and diseases
Respondent 3	yes. reduce competition for nutrients and ease management
Respondent 4	Yes, for proper agronomic practices eg intercropping to
Respondent 5	Proper spacing helps to avoid competition among crops for sunlight, nutrients, soil water, reduce on pests and disease infestation and multiplication rate
Respondent 6	Yes to avoid over shades To avoid competitions for nutrients To ease monitoring supervision
Respondent 7	It's. Determines available nutrients, controls pest movement

Respondent 8	It controls the spread of pests and diseases. It increases yields Easy to carry out farm operations.
Respondent 9	it gives good plant population it makes managemental practices easy it reduces nutrient competition
Respondent 10	Yes, good in knowing plant population and in developing a nutritional plan
Respondent 11	Yes . It ensure optimum plant population It determines Production and productivity
Respondent 12	To reduce competition for nutrients among plants. Allows proper garden solarization of crops for pest control. For proper weeding, spraying with pesticides and harvesting
Respondent 13	1. IT DETERMINES THE PLANT POPULATION AND HENCE FINAL DESIRED YIELDS. 2. PROPER SPACING AVOIDS OVERCROWDING HENCE PREVENTING PESTS AND DISEASE BUILD UP AND SPREAD.
Respondent 14	Yes 1. Reduces competition for nutrients between plants 2. Proper land use efficiency 3. Makes management activities like spraying, weeding etc easier to carry out
Respondent 15	Yes, spacing is very important. Because it reduces competition for light and other nutrients. Also poor spacing such as close spacing higher incidence of BCTB in coffee farms.
Respondent 16	It enables the coffee to receive enough light (sun) for proper flowering

41 What is the best shade tree for coffee? why?

Respondent 1	Back cloth tree
Respondent 2	Banana because they don't share same pests and diseases
Respondent 3	albiza
Respondent 4	Ficus and Musambya(Markhamia Lutea)
Respondent 5	Albizia spp & fig
Respondent 6	Ficus tree, Albizia,caliandra
Respondent 7	
Respondent 8	Not sure
Respondent 9	ficus, albizia cariandra
Respondent 10	Ficus ovata, ficus natalensis, ficus mucuso and albizia coriaria, they drop leaves and fruits which later give manure, the fruits attract flies
Respondent 11	Ficus natalenses . It is not a host for BCTB and it's leaves provide nutrients when decomposed.
Respondent 12	Grevellia
Respondent 13	MUGAIRE BECAUSE IT HS TOO THICH SAP THAT THE PEST CANNOT INHABIT IT.
Respondent 14	Musizi
Respondent 15	Albizia, mutuba, Acacia, musita
Respondent 16	Albizia

42 Are there any trees/intercrops that could act as a host for BCTB?

Respondent 1	yes
Respondent 2	yes
Respondent 3	yes
Respondent 4	yes
Respondent 5	yes
Respondent 6	yes
Respondent 7	yes
Respondent 8	no sure
Respondent 9	yes
Respondent 10	yes
Respondent 11	no
Respondent 12	yes
Respondent 13	yes
Respondent 14	yes
Respondent 15	yes
Respondent 16	no sure

43 If yes, specify the intercrop trees

Respondent 1	Back cloth tree
Respondent 2	Cocoa
Respondent 3	musambya and musizi
Respondent 4	Mseopsis
Respondent 5	Musizi and lusambya
Respondent 6	Avocado, Musizi
Respondent 7	Albizia
Respondent 8	0
Respondent 9	musizi, avacodo,
Respondent 10	Ovacado, mangoes, Jackfruit and Musizi
Respondent 11	0
Respondent 12	0
Respondent 13	1. AVOCADO, MUSIZI (UMBRELLA) TREE.
Respondent 14	musizi
Respondent 15	Maesopsis eminii (Musizi), Sand Olive (musambya
Respondent 16	0

44 Could you please describe why it acts as a host?

Respondent 1	Produces liquid which Kill the BCTB

Respondent 2	They have similar characteristics
Respondent 3	smell and have smile traits
Respondent 4	The pest loves harboring under it
Respondent 5	They have heavy canopies that provide conducive environment that harbors pests
Respondent 6	They are not repellant They feed on them
Respondent 7	Quick maturing and doesn't host pests
Respondent 8	
Respondent 9	it feeds on them its not repellant
Respondent 10	These are host trees for BCTB reason that the pest easily bores and hides in there
Respondent 11	
Respondent 12	
Respondent 13	BECAUSE THEY HAVE THIN QUANTITIES IN THEIR TISSUES HENCE EASILY INHABITED BY PEST
Respondent 14	N/A
Respondent 15	Because they harbor BCTB and they can also feed on them
Respondent 16	

45 What are the recommended intercrops with coffee?

Respondent 1	Banana Legumes
Respondent 2	6*6m
Respondent 3	yams, bananas, albizia, legume crops, mukuna
Respondent 4	Ficus sp
Respondent 5	Bananas, albizia spp, ficus spp, grevillea
Respondent 6	Albizia,ficus trees,coriander etc
Respondent 7	Banana coffee
Respondent 8	Not sure
Respondent 9	beans, soya g nuts
Respondent 10	Banana, gnuts, beans, soya beans, vanilla, elephant grass and good shade trees
Respondent 11	Banana, legumes
Respondent 12	Bananas-coffee Beans-Coffee
Respondent 13	BANANAS. REGUMES.
Respondent 14	Musizi
Respondent 15	Beans, Soybean, Velvet
Respondent 16	Legume crops to fix Nitrogen (Mucuna Beans)

46 What are the reasons for this selection?

Respondent 1	Less competition
Respondent 2	Both earns money and forms canopy when grown
Respondent 3	provide soil cover, add nutrients to soil, also food/income as we wait for coffee income
Respondent 4	It doesn't harbor the pest
Respondent 5	They add nitrogen in the soil and form a canopies that sun light to reach the coffee tree below them
Respondent 6	They are un friendly to the pest They improve on soil fertility They creat good shade for coffee
Respondent 7	High income
Respondent 8	Not sure
Respondent 9	they act as cover crops to reduce soil erosion and keeps moisture in the soil
Respondent 10	There is a symbiotic relationship
Respondent 11	They don't host coffee pests , they are not heavy feeders , can provide food to the farmer as he or she manages coffee before it yields
Respondent 12	Bananas give coffee seedlings shade when it's still young. Beans supply nitrogen to coffee.
Respondent 13	1. BANANAS IS A FOOD CROP YET COFFEE IS BASICALLY FOR CASH YET A FARMER HAS TO EAT. 2. REGUMES SUPPLEMENT THE NITROGEN IN THE SOIL.
Respondent 14	quick maturing and alternative hosts
Respondent 15	These crops are leguminous crops and they fix nitrogen into the soil which improves on the fertility of the soil
Respondent 16	Nitrogen fixation and control of weeds

47 What is the infestation level of the insect on shaded coffee vs non-shaded coffee?

Respondent 1	0,1
Respondent 2	more on non-shaded coffee
Respondent 3	more on shaded coffee
Respondent 4	more on shaded coffee
Respondent 5	more on shaded coffee
Respondent 6	more on non-shaded coffee
Respondent 7	more on shaded coffee
Respondent 8	not sure
Respondent 9	not sure
Respondent 10	more on shaded coffee
Respondent 11	more on shaded coffee
Respondent 12	more on shaded coffee
Respondent 13	more on non-shaded coffee
Respondent 14	not sure

Respondent 15	more on non-shaded coffee
Respondent 16	not sure

48 What is the reason behind this variation in the infestation levels?

Respondent 1	
Respondent 2	Because there is an alternative
Respondent 3	some shade treats are host plants, other provide conducive environment for borer growth
Respondent 4	Shaded coffee has more twigs to infest and many areas for the rest to hide
Respondent 5	Shade trees if no regularly trimmed they provide a conducive cool environment that harbors the pest during the dry season
Respondent 6	it creates room for breeding
Respondent 7	Shade Provide cover
Respondent 8	Not sure
Respondent 9	not sure
Respondent 10	Weather changes and shade levels associated to bad shade trees
Respondent 11	Shading provide micro climate for the BCTB to survive
Respondent 12	Reduced sunlight entering coffee canopy increases rate of multiplication of the pest.
Respondent 13	BRCAUSE THE SHADED PLANTANTIONS WITH TREES WHICH ARE NON HOSTS HELP TO INTERRUPT THE PEST LIFECYCLES
Respondent 14	
Respondent 15	Because non-shaded coffee is associated with warmer conditions which increases the incidence of BCTB
Respondent 16	

49 Are there any crops/trees which can act as a repellent plant for the BCTB?

Respondent 1	not sure
Respondent 2	not sure
Respondent 3	not sure
Respondent 4	yes
Respondent 5	not sure
Respondent 6	no
Respondent 7	not sure
Respondent 8	not sure
Respondent 9	not sure
Respondent 10	not sure
Respondent 11	no
Respondent 12	not sure
Respondent 13	yes
Respondent 14	not sure

Respondent 15	not sure
Respondent 16	not sure

50 If yes, specify the trees

Respondent 1	0
Respondent 2	0
Respondent 3	0
Respondent 4	Musambya
Respondent 5	N,/A
Respondent 6	N/A
Respondent 7	0
Respondent 8	Not sure
Respondent 9	not sure
Respondent 10	0
Respondent 11	N/A
Respondent 12	0
Respondent 13	1.ALBIZIA CHINENSIS
Respondent 14	0
Respondent 15	0
Respondent 16	0

51 Could you please describe what mechanism makes it repellent?

Respondent 1	0
Respondent 2	0
Respondent 3	0
Respondent 4	It gives out a scent move so during flowering
Respondent 5	N/A
Respondent 6	N/A
Respondent 7	Not sure
Respondent 8	Not sure
Respondent 9	not certain
Respondent 10	0
Respondent 11	N/A
Respondent 12	0
Respondent 13	THE LIFE CYCLE I.E LARVAE STAGES OF THE PEST CANNOT SURVIVE INSIDE THE TRANSPORT SYSTEM OF THE TREE SPECIES.
Respondent 14	0
Respondent 15	0

Respondent 16	0

52 Have you noted any predatory activity on the BCTB? (other insects, birds, etc.)

Respondent 1	Yes
Respondent 2	No
Respondent 3	0
Respondent 4	No
Respondent 5	No
Respondent 6	N/A
Respondent 7	Not yet
Respondent 8	Not sure
Respondent 9	not sure
Respondent 10	0
Respondent 11	No
Respondent 12	Yes
Respondent 13	FORMICID ANT
Respondent 14	no
Respondent 15	No
Respondent 16	no

53 Has there been any research work done on the BCTB in Uganda?

Respondent 1	no
Respondent 2	not sure
Respondent 3	yes
Respondent 4	yes
Respondent 5	yes
Respondent 6	yes
Respondent 7	yes
Respondent 8	not sure
Respondent 9	not sure
Respondent 10	yes
Respondent 11	yes
Respondent 12	yes
Respondent 13	yes
Respondent 14	yes
Respondent 15	yes
Respondent 16	not sure

54 If yes, in what way is it beneficial to the farmers?

Respondent 1	Not applicable
Respondent 2	
Respondent 3	farmers have learnt to buy clean planting materials from certified tree nurseries
Respondent 4	To know the right shade trees to intercrop with coffee
Respondent 5	It managed to come up with control measures that are being passed on the farmers
Respondent 6	it prepares them on how to minimize the infestation
Respondent 7	It provides information on control
Respondent 8	Not sure
Respondent 9	not sure
Respondent 10	More sensitisations have been made on BCTB control measures
Respondent 11	It informs management strategies for BCTB
Respondent 12	Research has prescribed for farmers the most appropriate methods for controlling the pest.
Respondent 13	FARMERS ARE NOW IMPLEMENTING THE CONTROL MEASURES, AND ALL OF THEM ARE FROM RESEARCH.
Respondent 14	It has not been disseminated yet
Respondent 15	Through the research, the farmers learnt ethanol technology of controlling BCTB. Also the farmers learnt the recommended tree species for planting in the coffee fields.
Respondent 16	

55 What is the rate of implementation of such works on farmer fields? (Out of 10)

Respondent 1	5
Respondent 2	0
Respondent 3	6
Respondent 4	5
Respondent 5	4
Respondent 6	5
Respondent 7	5
Respondent 8	0
Respondent 9	5
Respondent 10	4
Respondent 11	4
Respondent 12	4
Respondent 13	6
Respondent 14	1
Respondent 15	4
Respondent 16	5

Appendix 2: Interview answers from coffee farmers in Kamuli

Field Interviewee

Interviewee1	Eyiiga Jimmy	Kasaikye village, Namasagali, Kamuli district, Uganda
Interviewee2	Waiswt Henry	Buwaiswa,Uganda
Interviewee3	Mbeeko Saidi	Kavule, Namasagali, Kamuli town, Uganda
Interviewee4	Adonyi Saul	Kisaikye Nansololo Zone, Namasagali, Uganda
Interviewee5	Kiirya John	Kavule, Namasagali
Interviewee6	Sentonco David	Kabanyoro, Namasagali, Uganda
Interviewee7	Kuluse Noah	Buyala Zone Kasoyi, Kamuli town, Uganda
Interviewee8	Nabiryo Edisa	Kasozi, Luweero, Uganda
Interviewee9	Ibanda Jason	Kasozi, Bugweri, Uganda
Interviewee10	Amsemqawa Mukama David	Kasozi, Uganda

1 How many acres is your land around your homestead? how many acres is your coffee farm?

Interviewee 1	13-14/5
Interviewee 2	24/5
Interviewee 3	35/10
Interviewee 4	20/6
Interviewee 5	7/4
Interviewee 6	13/2
Interviewee 7	7/1
Interviewee 8	4/1
Interviewee 9	2.5/0.5
Interviewee 10	20.5/4

2 What are you growing in these lands, can you elaborate it?

Interviewee 1	coffee, banana, cocoa, avocado, Jackfruit
Interviewee 2	coffee, banana, Maesopsis eminii, cassava, maize, mongo
Interviewee 3	coffee, Maesopsis eminii, maize, peanut
Interviewee 4	coffee, banana, Maesopsis eminii, maize, sweet potato, orange, tomato
Interviewee 5	coffee, Maesopsis eminii, cocoa, cassava, ficus natalensis
Interviewee 6	coffee, banana, cassava, maize, bean, peanut
Interviewee 7	coffee, banana, cassava, maize, Jackfruit, sugarcane, tabbacco, sweet potato, papaya, tomato
Interviewee 8	coffee, banana, cassava, maize, bean, sweet potato
Interviewee 9	coffee, banana, cassava
Interviewee 10	coffee, banana, cassava, maize, sugarcane, bean

3 How many coffee plants do you have per acre?

Interviewee 1	450
Interviewee 2	450

Interviewee 3	500
Interviewee 4	450
Interviewee 5	375
Interviewee 6	450
Interviewee 7	450
Interviewee 8	500
Interviewee 9	450
Interviewee 10	400

4 How many coffee plants do you have in total?

Interviewee 1	4500
Interviewee 2	2250
Interviewee 3	5000
Interviewee 4	2700
Interviewee 5	1500
Interviewee 6	900
Interviewee 7	450
Interviewee 8	500
Interviewee 9	250
Interviewee 10	1640

5 How long have you been growing coffee?

Interviewee 1	7 years
Interviewee 2	3.5 years
Interviewee 3	20 years
Interviewee 4	10 years
Interviewee 5	25 years
Interviewee 6	2 years
Interviewee 7	20 years
Interviewee 8	10 years
Interviewee 9	5 years
Interviewee 10	20 years

7 What is the soil condition like in your coffee plantation?

Interviewee 1	poor
Interviewee 2	medium
Interviewee 3	good
Interviewee 4	good
Interviewee 5	good
Interviewee 6	poor
Interviewee 7	poor
Interviewee 8	good
Interviewee 9	poor
Interviewee 10	good

8 If it is poor, do you use any method to improve your soil condition?

Interviewee 1	Applying cow manure and chemical fertilizers (2-3 bag NPK per acre and 2-3 bags lime per acre),High acidity, lack of nutrients
Interviewee 2	applying animal manure, 100 bags pig manure for 5 arces per year and 13 bag (50kg per bag)chemical fertilizer, twice a year in wet season,because sandy-loam soil has poor nutrients keeping capacity
Interviewee 3	0
Interviewee 4	0
Interviewee 5	0
Interviewee 6	very dry, he doesn't use any method to improve soil condition
Interviewee 7	dry up very quick and can not contain mositure in soil , so put the prunned twigs into soil
Interviewee 8	mulching
Interviewee 9	ox-ploughing with then oxem
Interviewee 10	He does mulching in his coffe farm

9 What is the soil type?

Interviewee 1	sandy-loam
Interviewee 2	sansy
Interviewee 3	loam
Interviewee 4	sandy soil
Interviewee 5	0
Interviewee 6	sandy soil
Interviewee 7	sandy-loam
Interviewee 8	Loam
Interviewee 9	sand-loam soil
Interviewee 10	loam soil

10 How old are your coffee plants in your coffee farm?

Interviewee 1	1-7 years old
Interviewee 2	3-3.5
Interviewee 3	3-20 years old
Interviewee 4	3-10 years old
Interviewee 5	4-25 years old
Interviewee 6	2 years old
Interviewee 7	20-40 years old
Interviewee 8	12 years
Interviewee 9	6 years old
Interviewee 10	about 18 years old

11 what coffee variety plants do you grow?

Interviewee 1	robasta
Interviewee 2	robasta
Interviewee 3	robasta
Interviewee 4	robasta

Interviewee 5	robasta
Interviewee 6	robasta
Interviewee 7	robasta
Interviewee 8	robasta
Interviewee 9	robasta
Interviewee 10	robasta

12 Who takes care of the coffee garden?

Interviewee 1	permenent employee, part time employee
Interviewee 2	permenent employee, part time employee
Interviewee 3	female family member, male family member
Interviewee 4	female family member, male family member, kids in family
Interviewee 5	female family member, male family member, kids in family
Interviewee 6	female family member, male family member, kids in family, part time employee
Interviewee 7	female family member, male family member, kids in family, part time employee
Interviewee 8	female family member, male family member, kids in family
Interviewee 9	female family member, male family member, kids in family
Interviewee 10	female family member, male family member, kids in family, part time employee

13 What is the role of female family member in coffee garden?

Interviewee 1	none
Interviewee 2	none
Interviewee 3	harvesting, growing, weeding, mulching
Interviewee 4	harvesting, weeding, pruning
Interviewee 5	harvesting, weeding, pruning
Interviewee 6	harvesting, weeding, pruning
Interviewee 7	harvesting, weeding
Interviewee 8	weeding
Interviewee 9	harvesting, weeding
Interviewee 10	harvesting, weeding

14 What is the role of male family member in coffee garden?

Interviewee 1	none
Interviewee 2	supervision and decision making
Interviewee 3	harvesting, irrigation, spreading fertilizers, growing, weeding, pruning, mulching
Interviewee 4	harvesting, growing, weeding, pruning
Interviewee 5	harvesting, growing, weeding, pruning
Interviewee 6	supervision
Interviewee 7	spraying pesticide, weeding, pruning, mulching
Interviewee 8	harvesting, growing, weeding
Interviewee 9	harvesting, growing

Interviewee 10	harvesting, growing, weeding

15 What is the role of a kid family member in a coffee garden?

Interviewee 1	none
Interviewee 2	none
Interviewee 3	harvesting, weeding, mulching
Interviewee 4	harvesting, weeding
Interviewee 5	harvesting, weeding
Interviewee 6	harvesting, weeding
Interviewee 7	harvesting
Interviewee 8	weeding
Interviewee 9	weeding
Interviewee 10	harvesting

16 What is the role of permanent employee in coffee garden?

Interviewee 1	harvesting, irrigation, spraying pesticide, spreading fertilizers, growing, weeding
Interviewee 2	harvesting, irrigation, spraying pesticide, spreading fertilizers, growing, weeding
Interviewee 3	none
Interviewee 4	none
Interviewee 5	none
Interviewee 6	none
Interviewee 7	none
Interviewee 8	none
Interviewee 9	none
Interviewee 10	none

17 What is the role of a part time employee in a coffee garden?

Interviewee 1	harvesting, weeding
Interviewee 2	harvesting, spreading fertilizers
Interviewee 3	spreading fertilizers, mulching
Interviewee 4	harvesting
Interviewee 5	none
Interviewee 6	spreading fertilizers, growing, weeding, pruning
Interviewee 7	growing, weeding
Interviewee 8	none
Interviewee 9	none
Interviewee 10	growing, weeding

18 Do you work on the coffee farm?

Interviewee 1	yes
Interviewee 2	yes
Interviewee 3	yes
Interviewee 4	yes
Interviewee 5	yes

Interviewee 6	yes
Interviewee 7	yes
Interviewee 8	yes
Interviewee 9	yes
Interviewee 10	yes

19 How did you space your coffee when planting them? Why?

Interviewee 1	10 feet by 10 feet
Interviewee 2	10 by 10 feet, enough space for growing
Interviewee 3	10 feet by 10 feet, leave space for intercropping and enough for coffee growing
Interviewee 4	10 feet by 10 feet, don't interact with other coffee trees
Interviewee 5	12 feet by 12 feet, provide enough space for coffee plant and other intercrops growing
Interviewee 6	10 feet by 10 feet
Interviewee 7	10 feet by 10 feet, because this intensity is recommended by experts
Interviewee 8	10 feet by 10 feet, because it provides enough space for coffee growing
Interviewee 9	10 feet by 10 feet, he is followed the recommendation from the extension worker
Interviewee 10	0

20 Do you practice intercropping with your coffee cultivation?

Interviewee 1	Maesopsis eminii (Musizi), Jackfruit, Banana
Interviewee 2	Ficus natalensis (Mutuba or Natal fig), Mango, Maize, Banana
Interviewee 3	Maesopsis Eminii (Musizi), Mango, Avocado, Maize, Banana, Soybean, cassava, oranges
Interviewee 4	Maesopsis Eminii (Musizi), Jackfruit, Maize, Banana, peanuts
Interviewee 5	Maesopsis Eminii (Musizi), Jackfruit, Avocado, Maize, Banana, Soybean, cocoa
Interviewee 6	Maesopsis Eminii (Musizi e), Jackfruit, Mango, Banana, Soybean, orange, Neemtree
Interviewee 7	Ficus natalensis (Mutuba or Natal fig), Jackfruit, Banana, Soybean, peanuts, tabbacca
Interviewee 8	Jackfruit, Mango, Avocado, Maize, Banana, oranges
Interviewee 9	Jackfruit, Mango, Banana, orange
Interviewee 10	Jackfruit, Mango, Maize, Banana

21 Why do you select intercropping crops for your coffee cultivation?

Interviewee 1	Shading, Manure (fertility), Home consumption, Remain moisture in soil and reduce water lacking
Interviewee 2	Shading, Home consumption, Getting income
Interviewee 3	Shading, Manure (fertility), Firewood, Bark cloth, Home consumption, Getting income, animal feed

Interviewee 4	Shading, Manure (fertility), Firewood, Native tree, Home consumption, Getting income, animal feed
Interviewee 5	Shading, Manure (fertility), Firewood, Timber, Home consumption, Getting income
Interviewee 6	Shading, Timber, Home consumption, Getting income
Interviewee 7	Shading, Firewood, Timber, Home consumption
Interviewee 8	Shading
Interviewee 9	Shading, Firewood, Timber
Interviewee 10	Shading, Firewood, Timber

22 What spacing do you typically maintain between intercropped crops and your coffee plants? Why?

Interviewee 1	He was randomly growing the intercropped tree, like jackfruit, Maesopsis Eminii and banana.
Interviewee 2	10 by 20 feet
Interviewee 3	0
Interviewee 4	1 tree between two coffee plant
Interviewee 5	5 feet from coffee tree
Interviewee 6	10 feet by 10 feet
Interviewee 7	80 feet for Ficus Natalensis, 12 feet to 15 feet for banana
Interviewee 8	five feet
Interviewee 9	no standard spacing, he maintain between intercropped crop
Interviewee 10	10 feet by 10 feet

23 How do you approach fertilization management in your coffee cultivation?

Interviewee 1	Using NPK and Lime 2-3 bags per year, respectively. radomly using cow manure, about onceduring 6 month to 1 year
Interviewee 2	applying animal manure, 100 bags pig manure for 5 arces per year and 13 bag (50kg per bag)chemical fertilizer, twice a year in wet seaso
Interviewee 3	applying cow manure(get from neighbor livestock farmers), and using sugarcane and maize leaves to mulch the field
Interviewee 4	Dig stretch between two trees in wet season and applying cow manure and compost of the cutted grass in dry season,
Interviewee 5	no fertilizers
Interviewee 6	using animal manure, 1500kg per year
Interviewee 7	applying the ash and animal manure, and also using foliar fertilizer and NPK
Interviewee 8	0
Interviewee 9	no
Interviewee 10	0

24 How important is coffee for the total family revenue? (On a scale of 1 to 10)

Interviewee 1	5
Interviewee 2	4
Interviewee 3	8

Interviewee 4	9
Interviewee 5	7
Interviewee 6	4
Interviewee 7	7
Interviewee 8	4
Interviewee 9	4
Interviewee 10	5

25 Is your farm family-run business?

Interviewee 1	yes
Interviewee 2	yes
Interviewee 3	yes
Interviewee 4	yes
Interviewee 5	yes
Interviewee 6	yes
Interviewee 7	yes
Interviewee 8	yes
Interviewee 9	yes
Interviewee 10	yes

26 How are the challenges in coffee cultivation?
a. Pests and diseases

No.	a. Pests and diseases	b.Marketability and selling	c. Proper returns	d.Extension service delivery	e. soil quality	f. water supply, irrigation system	g. Road access	h. thief
Interviewee 1	9	3	9	9	10	10	5	3
Interviewee 2	5	1	3	3	0	0	0	3
Interviewee 3	10	1	1	10	6	7	8	4
Interviewee 4	9	6	6	3	3	7	8	2
Interviewee 5	9	6	8	10	2	5	10	1
Interviewee 6	5	1	1	5	3	9	8	5
Interviewee 7	3	10	10	10	7	7	10	6
Interviewee 8	9	5	5	10	4	6	7	3
Interviewee 9	10	3	3	2	9	7	7	2
Interviewee 10	8	4	5	5	4	4	5	2

27 Are you a member of an association/ cooperative/ group? And What is the name of the association/ cooperative/ group?

Interviewee 1	Yes
Interviewee 2	Yes
Interviewee 3	No
Interviewee 4	No
Interviewee 5	No
Interviewee 6	No
Interviewee 7	Yes

Interviewee 8	No
Interviewee 9	No
Interviewee 10	No

28 If yes, please elaborate it.

Interviewee 1	Eastern coffee working group Subscribed for NUCAFE members in a whatsapp group
Interviewee 2	Kabukye coffee farmer association
Interviewee 3	0
Interviewee 4	0
Interviewee 5	0
Interviewee 6	0
Interviewee 7	local coffee cooperative primary group local saving group- saving money for future use Jeka poultry farmer association - provide advices regarding raise poultry
Interviewee 8	0
Interviewee 9	0
Interviewee 10	0

29 Where do you source your coffee planting material?

Interviewee 1	local market
Interviewee 2	local market, UCDA provide seedling
Interviewee 3	local market, home seedling
Interviewee 4	local market
Interviewee 5	local market
Interviewee 6	local market
Interviewee 7	local market
Interviewee 8	local market
Interviewee 9	local market
Interviewee 10	local market

30 Is it easy to access the government extension service regarding pest management and farming practices?

Interviewee 1	difficult
Interviewee 2	easy
Interviewee 3	difficut
Interviewee 4	difficult
Interviewee 5	difficult
Interviewee 6	difficult
Interviewee 7	difficult
Interviewee 8	indifferent
Interviewee 9	easy
Interviewee 10	indifferent

31 Could you please talk about the motivation behind your coffee cultivation?

Interviewee 1	inherited from last generation, good income
Interviewee 2	good income, government extension and advice
Interviewee 3	good income, government extension and advice
Interviewee 4	inherited from last generation, good income
Interviewee 5	easy to grow
Interviewee 6	good income
Interviewee 7	inherited from last generation, good income
Interviewee 8	good income
Interviewee 9	good income
Interviewee 10	good income

32 Could you please elaborate on the sources from which you acquire knowledge and expertise regarding coffee cultivation practices?

Interviewee 1	sub-county officer, association
Interviewee 2	sub-county officer, google search and extension service
Interviewee 3	TV, Radio
Interviewee 4	sub-county officer
Interviewee 5	Radio
Interviewee 6	sub-county officer
Interviewee 7	sub-county officer, family member, TV, Radio, seedling supplier, agricultural collage
Interviewee 8	sub-county officer, neighbors and friends
Interviewee 9	sub-county officer
Interviewee 10	sub-county officer, TV, Radio

33 How do you sell your coffee and how has the coffee selling situation been for you lately?

Interviewee 1	second middleman
Interviewee 2	company
Interviewee 3	local middleman
Interviewee 4	local middleman
Interviewee 5	local middleman
Interviewee 6	second middleman
Interviewee 7	local middleman, used to selling to the cooperative company, afterwards it fails
Interviewee 8	local middleman
Interviewee 9	local middleman
Interviewee 10	local middleman

34 How is the price of coffee cherry/dried bean you get?

Interviewee 1	4500 USH per kilogram for dried cherry
Interviewee 2	10,000 ush milled bean; 5,000 ush dried cherry
Interviewee 3	4500USH for dried cherry, 2000 UGH for fresh cherry
Interviewee 4	4000 ush for dried cherry
Interviewee 5	5000 ush per kg for dried cherry and 2000 Ush per kg for fresh cherry

Interviewee 6	8000 ush milled bean
Interviewee 7	2500USH fresh cherry
Interviewee 8	
Interviewee 9	4500ush per kg for dried cherry
Interviewee 10	the coffee price lately was bad

35 Have you observed any pests affecting your coffee plants? If so, could you elaborate on the impact these pests have had on your coffee crop?

Interviewee 1	He already found BCTB for 3 years, and he found other fungi disease becase blacken bean and leaves on coffee trees.
Interviewee 2	yes, there are some pest in coffee garden
Interviewee 3	yes
Interviewee 4	yes
Interviewee 5	yes, see some BCTB
Interviewee 6	no, just see the some symptom of the coffee
Interviewee 7	BCTB, don't know others
Interviewee 8	yes, because the yields have gone low
Interviewee 9	yes
Interviewee 10	yes, they are so common on my coffee plantation

36 Are you familiar with the signs or symptoms that indicate the presence of these pests on your coffee?

Interviewee 1	Blackening coffee cherry, Wilted and dried twigs
Interviewee 2	Wilting and drying of leaves, Wilted and dried twigs, Drying of the whole coffee plant
Interviewee 3	Blackening coffee cherry, Discovering of entry holes on twigs, falling leaves, dried cherry
Interviewee 4	Wilting and drying of leaves, Blackening coffee cherry, Wilted and dried twigs, Discovering of entry holes on twigs
Interviewee 5	Wilting and drying of leaves, Blackening coffee cherry, Wilted and dried twigs, Discovering of entry holes on twigs
Interviewee 6	Wilting and drying of leaves, Wilted and dried twigs, Black pest that makes holes in twigs and lay their eggs inside
Interviewee 7	Blackening coffee cherry, Wilted and dried twigs, Drying of the whole coffee plant
Interviewee 8	Blackening coffee cherry, Wilted and dried twigs, Drying of the whole coffee plant
Interviewee 9	Wilting and drying of leaves, Drying of the whole coffee plant
Interviewee 10	Blackening coffee cherry, Wilted and dried twigs, Drying of the whole coffee plant, Discovering of entry holes on twigs

37 Do you know Black Coffee twig borer?

Interviewee 1	Yes
Interviewee 2	Yes
Interviewee 3	Yes

Interviewee 4	Yes
Interviewee 5	Yes
Interviewee 6	Yes
Interviewee 7	Yes
Interviewee 8	Yes
Interviewee 9	Yes
Interviewee 10	Yes

38 If so, how do you know this pest? and do you know how it affects your coffee plantation?

Interviewee 1	He has known BCTB from sub-county agricultural officers. This insect make twig wilt and reduce the yield of coffee cheery.
Interviewee 2	0
Interviewee 3	yield loss
Interviewee 4	yield losses
Interviewee 5	0
Interviewee 6	He got to know the BCTB from radio and know it's synptoms but don't know how it looks like.
Interviewee 7	5 years
Interviewee 8	the twigs is becoming dry
Interviewee 9	yes, it dried up the twig
Interviewee 10	it will lead to the drying of twigs and entry hole on the twigs

39 Have you encountered issues with the Black Coffee Twig Borer affecting your farm?

Interviewee 1	Yes
Interviewee 2	0
Interviewee 3	Yes
Interviewee 4	Yes
Interviewee 5	Yes
Interviewee 6	Yes
Interviewee 7	No
Interviewee 8	Yes
Interviewee 9	Yes
Interviewee 10	Yes

40 If so, could you provide an estimate of the yield or quality loss experienced per hectare due to this pest?

Interviewee 1	about 30%
Interviewee 2	0,2
Interviewee 3	0,4
Interviewee 4	0,5
Interviewee 5	0,2
Interviewee 6	he doesn't know
Interviewee 7	0,2
Interviewee 8	0,5
Interviewee 9	0,4

Interviewee 10	40-50%

41 What symptoms does the BCTB have?

Interviewee 1	Entry Holes on twigs, Wilting of twigs, Drying of twigs, Drying of leaves
Interviewee 2	Seeing the pest inside the twigs, Seeing the eggs of the pest inside the twigs, Entry Holes on twigs, Drying of twigs, Wilting of leaves
Interviewee 3	Entry Holes on twigs, Wilting of leaves, Drying of leaves
Interviewee 4	Entry Holes on twigs, Wilting of twigs, Drying of twigs, Twigs changes color to black, Wilting of leaves
Interviewee 5	Entry Holes on twigs, Drying of twigs, Wilting of leaves, Falling of leaves
Interviewee 6	Entry Holes on twigs, Drying of twigs, Drying of leaves
Interviewee 7	Entry Holes on twigs, Wilting of twigs, Drying of twigs
Interviewee 8	Drying of twigs, Drying of leaves
Interviewee 9	Drying of twigs, Drying of leaves
Interviewee 10	Entry Holes on twigs, Drying of twigs

42 For how long have you had problems with BCTB?

Interviewee 1	more than 3 years
Interviewee 2	1-1.5 years
Interviewee 3	10 years
Interviewee 4	5 years
Interviewee 5	10 years
Interviewee 6	1 year
Interviewee 7	5 years
Interviewee 8	5 years
Interviewee 9	3 years
Interviewee 10	6 years

43 How has the intensity of the problem changed over time?

Interviewee 1	reduced
Interviewee 2	reduced
Interviewee 3	reduced
Interviewee 4	increased a lot
Interviewee 5	reduced
Interviewee 6	increased a lot
Interviewee 7	reduced
Interviewee 8	reduced
Interviewee 9	increased a lot
Interviewee 10	inceased

44 When is the BCTB most active?

Interviewee 1	The most active time is in dry season(from december to march)
Interviewee 2	dry season from december to march

Interviewee 3	worse in dry season
Interviewee 4	active in dry season because he found more entry holes on the twigs
Interviewee 5	dry season
Interviewee 6	dry season from January to March
Interviewee 7	dry season
Interviewee 8	dry seasom
Interviewee 9	dry season
Interviewee 10	in dry season

45 Do you have a special area in your coffee plantation where you experience most problems with the BCTB?

Interviewee 1	no
Interviewee 2	No
Interviewee 3	No
Interviewee 4	No
Interviewee 5	Yes
Interviewee 6	No
Interviewee 7	No
Interviewee 8	Yes
Interviewee 9	No
Interviewee 10	No

46 Do you use any chemicals to control the BCTB? If yes, name, how much/often?

Interviewee 1	using pesticide Black off
Interviewee 2	Yes
Interviewee 3	No
Interviewee 4	No
Interviewee 5	No
Interviewee 6	Yes
Interviewee 7	0
Interviewee 8	No
Interviewee 9	No
Interviewee 10	No

47 How do you control the BCTB infestation?

Interviewee 1	Remove the infested branches, Burning the infested branches, weeding
Interviewee 2	Manage coffee plants(pruning, reduce roots), Remove the infested branches, Burning the infested branches, Applying manure, Remove sprouts, Cut down the whole infested tree
Interviewee 3	Remove the infested branches, Burning the infested branches
Interviewee 4	Manage coffee plants(pruning, reduce roots), Remove the infested branches, Burning the infested branches, weeding
Interviewee 5	Remove the infested branches, Burning the infested branches

Interviewee 6	Remove the infested branches, Burning the infested branches, spraying the pesticides which got from local government but stopped later
Interviewee 7	Remove the infested branches, Burning the infested branches, weeding
Interviewee 8	Remove the infested branches, Burning the infested branches
Interviewee 9	Remove the infested branches
Interviewee 10	Remove the infested branches, Burning the infested branches

48 Have you seen anything feeding on the BCTB? (Enemies of the BCTB: insects, birds, lizards...)

Interviewee 1	0
Interviewee 2	No
Interviewee 3	No
Interviewee 4	No
Interviewee 5	Yes
Interviewee 6	No
Interviewee 7	0
Interviewee 8	No
Interviewee 9	No
Interviewee 10	No

49 Do you think there is a relationship between trees and the BCTB?

Interviewee 1	Yes
Interviewee 2	Yes
Interviewee 3	Yes
Interviewee 4	No
Interviewee 5	No
Interviewee 6	Yes
Interviewee 7	Yes
Interviewee 8	No
Interviewee 9	No
Interviewee 10	No

50 If yes, in what way?

Interviewee 1	0
Interviewee 2	he doesn't know
Interviewee 3	the tree can be shade tree for coffee, but BCTB infestastion can be increased under the tree
Interviewee 4	0
Interviewee 5	0
Interviewee 6	some trees make BCTB infestation worse, like Maesposis eminii
Interviewee 7	tree can provide shade for coffee and comfortabble environemnt
Interviewee 8	0
Interviewee 9	0
Interviewee 10	0

51 Do you think there is a relationship between crops and the BCTB?

Interviewee 1	0
Interviewee 2	Yes
Interviewee 3	No
Interviewee 4	No
Interviewee 5	No
Interviewee 6	No
Interviewee 7	Yes
Interviewee 8	No
Interviewee 9	No
Interviewee 10	No

52 If yes, in what way?

Interviewee 1	0
Interviewee 2	he doesn't know
Interviewee 3	0
Interviewee 4	0
Interviewee 5	0
Interviewee 6	0
Interviewee 7	0
Interviewee 8	0
Interviewee 9	0
Interviewee 10	0

53 If you compare a coffee in the shade and non-shaded tree – which has the most problem with BCTB?

Interviewee 1	more on non-shaded tree
Interviewee 2	more on the shaded tree
Interviewee 3	more on the shaded tree
Interviewee 4	more on the shaded tree
Interviewee 5	more on non-shaded tree
Interviewee 6	more on the shaded tree
Interviewee 7	more on the shaded tree
Interviewee 8	more on the shaded tree
Interviewee 9	more on the shaded tree
Interviewee 10	more on the shaded tree

54 Have you gotten any advice concerning the BCTB?

Interviewee 1	Yes
Interviewee 2	Yes
Interviewee 3	Yes
Interviewee 4	Yes
Interviewee 5	No
Interviewee 6	No
Interviewee 7	Yes

Interviewee 8	Yes
Interviewee 9	Yes
Interviewee 10	Yes

55 And where do you get the advice?

Interviewee 1	Get some advices from sub-county officers
Interviewee 2	online, google research
Interviewee 3	TV program
Interviewee 4	sub-county agricultural officers
Interviewee 5	0
Interviewee 6	0
Interviewee 7	college
Interviewee 8	radio(talk show in KBS and Basoga One)
Interviewee 9	extension worker/sub-county agricultural officers
Interviewee 10	sub-county agricultural officers, radio and TV talks

56 Future plan

Interviewee 1	Eager to grow more coffee because the good income Sell coffee to big company for more added value
Interviewee 2	0
Interviewee 3	he is expanding 10 acres farmland to grow coffee
Interviewee 4	he is thinking of expanding coffee growing but no land to expand
Interviewee 5	no
Interviewee 6	He is going to expand 10 acres coffee growing.
Interviewee 7	expand the coffee growing
Interviewee 8	0
Interviewee 9	0
Interviewee 10	0