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Research Article

# Black Coffee Twig Borer Management Practices and Their Effect on Coffee Yields Among Smallholder Farmers in Lwanda Sub County, Rakai District

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## Abstract

The study focused on assessing Black Coffee Twig Borer (BCTB) management practices and their effect on coffee yields among smallholder farmers in Lwanda sub county, Rakai district. It was limited to; establishing the management practices used to control BCTB among the coffee farmers, identify the socio-economic factors influencing the use of Black Coffee Twig Borer management practices among smallholder farmers and analyzing the effects of BCTB on coffee yields. The study employed a cross-sectional research design and primary data was collected from 200 respondents. The data was analysed using SPSS version 22.0. The study used questionnaires and interview guide to collect data. The results indicate that the commonly used Black Coffee Twig Borer (BCTB) management practices, which included regular pruning ($p = 0.000$), removal and burning of infested twigs, (p-value=0.000), shade regulation (p-value =0.001), timely harvesting,(p-value =0.003) and chemical control method (p-value =0.007), all had a statistically significant effect ($p < 0.05$) on managing the of BCTB. The study recommends that, there is a need for capacity building for farmers, encourage farmers to adopt a combination of effective practices under an Integrated Pest Management approach, improve access to credit and financial services, strengthen policy and institutional support and promote positive attitudes and awareness campaign.

## Keywords

Black Coffee Twig Borer, Management Practices, Coffee Yields

## 1. Introduction

Globally, Coffee is one of the most widely traded agricultural commodities in the world, with an estimated 125 million people depending on it for their livelihoods [3]. However, coffee production faces numerous challenges, including climate change, diseases, and pests. Among the pests, the Black Coffee Twig Borer has emerged as a significant threat, particularly in tropical and subtropical coffee-growing regions. This pest is known for its ability to cause extensive damage to coffee plants by boring into the twigs, leading to reduced yields and lower coffee quality. For instance, in Southeast Asia, the pest has caused up to 80% yield losses in severely infested areas [16].

In Africa, coffee is a critical export commodity, particularly in East African countries like Uganda, Ethiopia, and Kenya. Uganda, the largest exporter of coffee in Africa, has seen its coffee production increasingly threatened by the Black Coffee

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Twig Borer [16]. The pest has become a major concern for smallholder farmers who constitute the majority of coffee producers in the country. The impact of this pest on coffee production is profound, with reports indicating that it can cause yield losses ranging from 30% to 40% if not properly managed [15]. for example in Kenya, the pest has similarly affected coffee yields, leading to significant economic losses for smallholder farmers. Despite various management practices being recommended, including cultural, chemical, and biological methods, the adoption and effectiveness of these practices vary widely among farmers [16]. This variability highlights the need for targeted interventions and more effective dissemination of knowledge to combat the pest and safeguard coffee production.

In Uganda, Black Coffee Twig Borer *Xylosandrus compactus* (Eichhoff) infestation is a major threat to coffee productivity, causing significant economic losses to coffee growers and affecting the global coffee supply chain [9]. In Uganda, two different varieties of coffee – Robusta and Arabica coffee [4]. Robusta coffee is native to Uganda and is widely cultivated in about 80% of the total coffee production area, grown mostly in the lowland regions of the country covering Central, eastern, mid north, West Nile, and western Uganda that are within 900 – 1500m above sea level [9, 12]. Rakai District, is a key coffee-producing region known for its favorable climate and fertile soils, making it an ideal area for coffee cultivation. Smallholder farmers in this district heavily depend on coffee as their primary source of income [7]. However, the productivity of coffee in Rakai has been increasingly compromised by the Black Coffee Twig Borer (BCTB), a pest that has emerged as a significant threat to the coffee industry in Uganda [8].

## 2. Problem Statement

In an ideal scenario, smallholder farmers in Rakai District would have access to effective and affordable management practices that control the Black Coffee Twig Borer, leading to optimal coffee yields [9]. The integration of these practices would result in minimal pest infestation, healthier coffee plants, and consistent high yields [4]. The reality in Rakai District, however, is far from ideal. Many smallholder farmers struggle with the effective implementation of management practices due to various constraints, such as limited access to resources, inadequate knowledge of pest control methods, and financial limitations [5]. As a result, the Black Coffee Twig Borer continues to pose a significant threat to coffee yields. The persistence of this pest has been reported to cause a substantial reduction in coffee production, where the study has shown that pest can reduce coffee yields by approximately 30-40%, depending on the severity of the infestation and the effectiveness of management practices employed by farmers [14]. The high infestation rates are exacerbated by inadequate management practices, leading to considerable economic losses for smallholder farmers, who rely heavily on coffee as a source of income. There is a research gap in understanding the specific effectiveness of different management practices in reducing the impact of the Black Coffee Twig Borer on coffee yields among smallholder farmers [15]. Although various methods have been recommended, there is limited empirical evidence on which practices are most effective under the specific conditions of smallholder farming in Rakai District. Moreover, there was a need to find out the BCTB management practices employed by coffee farmers, socio-economic factors influencing the use of Black Coffee Twig Borer management practices as well as analyzing the effects of management practices on coffee yields.

## 3. Research Objectives

The general objective of the study was to; assess management practices of Black Coffee Twig Borer (BCTB) as well as its effect on coffee yields in Lwanda sub county. The specific objective was to; establish the management practices used to control BCTB among the coffee farmers.

## 4. Significance of Study

The study is crucial for smallholder farmers as it will provide insights into effective management practices for controlling BCTB, ultimately helping to improve coffee yields and income. By identifying the most successful practices, farmers can adopt more efficient methods to reduce losses caused by BCTB. The findings will be valuable for agricultural extension workers who can use the information to guide farmers on best practices for managing BCTB. This can lead to better advisory services and support for smallholder farmers in Rakai District and beyond. For policymakers, the study will highlight the need for targeted interventions to control BCTB and support smallholder farmers. The results could inform the development of policies and programs aimed at improving pest management in coffee farming, ensuring sustainable coffee production.

The study will contribute to the existing body of knowledge on coffee pest management, providing a basis for further research in other regions or on other coffee pests. It can also serve as a reference for future studies on the impact of pest management practices on coffee yields. For stakeholders in the coffee industry, such as coffee buyers and processors, the study will provide insights into the quality and quantity of coffee produced by smallholder farmers. Understanding the impact of BCTB management on yields can help in planning for supply chain management and ensuring a consistent supply of quality coffee.

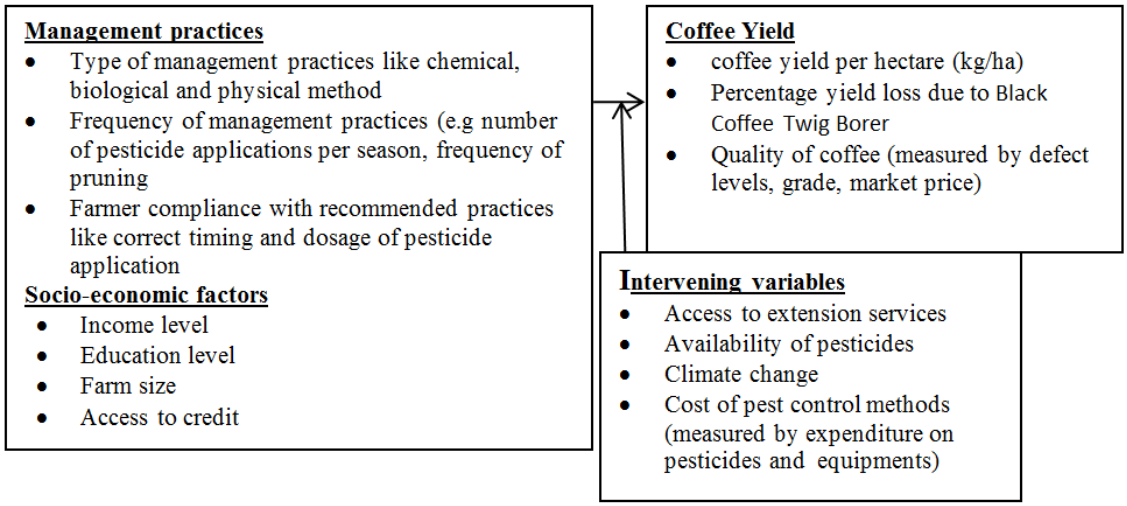
## 5. Justification of the Study

Assessment of the Management Practices and Effects of Black Coffee Twig Borer on Coffee Yields Among Small-

holder Farmers in Lwanda Sub-County, Rakai District is justified due to the significant threat posed by the Black Coffee Twig Borer (BCTB) to coffee production, a major income source for smallholder farmers in Uganda. Coffee contributes substantially to the livelihoods of these farmers, but the BCTB infestation has been a critical challenge, reducing yields and thus affecting income and food security [6]. This study aims to address the lack of sufficient information on the effectiveness of management practices for controlling BCTB in Lwanda Sub-County. Understanding these practices and their impact on yields will provide vital insights into improving productivity and reducing economic losses. Additionally, the study will help identify knowledge gaps among farmers and highlight areas needing further training or support, contributing to better pest management strategies. The findings are expected to benefit multiple stakeholders, including local farmers, agricultural extension officers, and policymakers, by providing evidence-based recommendations for managing BCTB. Ultimately, this study will play a crucial role in empowering smallholder farmers in Lwanda Sub-County with practical solutions for managing BCTB, ensuring sustainable coffee production, and maintaining the livelihoods dependent on this vital crop, thereby fostering community resilience and economic stability.

## 6. Conceptual Frame Work

*Independent variable Dependent variable*




Source: Self generated, 2025

***Figure 1.*** *Conceptual framework.*

## 7. Materials and Methods

The study was carried out in Lwanda subcounty (0 °39'48.2"S, 31 °27'16.5"E) located in Rakai District which is situated is in western part of central region of Uganda.

The average rainfall received in the area is about 1300mm per annum. There are two rainfall regimes, the first season begins in for example March to June and the other in for example August to December. These are punctuated by two dry spells in July to September and between January to February. The district experiences mean annual maximum temperature of for example 20 ℃ and mean annual minimum temperature of 14.5 ℃. The two sub counties were selected because they were robusta coffee production hubs in Rakai district.

The study used a cross-sectional study design which is a type of observational research that analyzed data from a population or a representative subset at a single point in time. This design was used to determine the prevalence of certain factors or outcomes and to explore associations between variables.

In the context of assessing the Coffee Twig Borer management practices and effects on coffee yields among smallholder farmers in Lwanda Sub-County, Rakai District, the cross-sectional study design involved; collecting quantitative and qualitative data from a sample of coffee farmers, extension agents and local leaders at a specific time. This included information on; current BCTB management practices, farmers' knowledge, attitudes, and socio-economic factors influencing the use of BCTB management practices, Coffee yields over the recent harvest period, severity of BCTB infestation and correlation between management practices and coffee yields. This design was suitable for the study because it is faster and less resource-intensive than longitudinal studies, making it ideal for resource-limited settings such as small-

holder and large coffee farming communities. The design provided immediate data that stakeholders (for example, local government, extension workers, and coffee unions) used it to inform interventions to mitigate BCTB's impact.

The study population involved smallholder coffee farmers as these were the primary respondents since they are directly involved in coffee cultivation and are affected by BCTB infestations. The focus on smallholder farmers was essential because they made up the majority of coffee producers in the sub-county and their practices directly influence coffee yields. Agricultural extension officers which included individuals provided technical support and advice to farmers on pest management practices. They had insights into the effectiveness of different BCTB management strategies and the challenges faced by farmers. Local agricultural leaders which included groups often played a role in disseminating information about pest management and had data on the adoption rates and effectiveness of various practices among farmers.

Simple random sampling was used to select a representative sample of smallholder coffee farmers from the target population. This method involved randomly selecting farmers from a complete list of smallholder coffee farmers in Lwanda Sub-County. Each farmer would have an equal chance of being selected, ensuring that the sample is representative of the broader population. The researcher created a list of all smallholder coffee farmers in Lwanda Sub-County and assign each a number. Use a random number generator to select the required number of farmers for the sample. This technique ensured that every farmer has an equal chance of being selected, reducing selection bias and allowing for generalizable results regarding the effects of BCTB management practices on coffee yields.

Purposive sampling involved intentionally selecting specific respondents who were particularly knowledgeable or relevant to the research question. This method was used to choose agricultural extension officers, local agricultural leaders, who had in-depth knowledge of BCTB management practices in the area. The researcher identified key agricultural extension officers and leaders who were actively involved in coffee pest management in Lwanda Sub-County. These category of respondents were selected based on their experience, involvement in pest management initiatives, or their leadership role in local agricultural practices.

The sample size was determined by [17] formula since the population of the study area is known and documented at both subcounty and district levels. This formula is written as

$$n = N/1+N\ (e)^2 \quad (1)$$

Where: n signifies the sample size, N signifies the population under study, and e is the margin of error. Using equation (1), a target population of 412 and a margin of error of 0.05, then

$$n = 412/1+412\ (0.05)^2 = 203$$

Therefore, 203 respondents were used in this study to provide insights into the investigation.

The structured questionnaires was distributed to respondents, primarily coffee farmers. This had both open and closed ended questions in relation to study objectives. These individuals were directly involved in daily coffee operations and had firsthand experience with BCTB and coffee yields. Questionnaires were used to collect data quantitative from individual respondents/coffee farmers, and these were translated in the local language to enable easy collection of relevant data.

The researcher conducted interviews with key informants with a help of an interview guide reflecting the study objectives. With this instrument, the researcher engaged key informants like extension agents and local leaders in oral questions in accordance with the study objectives. The interviews were necessary as they were widely used to supplement and extend the researchers' knowledge about individual (s) thoughts, feelings and behaviors (Brown & Garcia, 2020). While interviewing, probing was applied in cases where respondents did not give inadequate answers or where respondents get confused of the meanings. This was done in relation to study objectives.

The ethical clearance was obtained from Bishop Stuart University Research Ethics committee.

*Informed consent:* this involved ensuring that all participants are fully aware of the nature of the study, what their participation entailed, the potential risks, and their right to withdraw at any time without penalty.

The researcher clearly explained the purpose of the study, the procedures involved and the expected duration of participation. Participants were informed that their involvement was entirely voluntary, and they could choose to opt out at any stage of the research without any negative consequences.

Written consent forms were provided to all participants, ensuring they had understood the information provided and agree to participate.

*Respect for respondent's autonomy and dignity:* Respondents had the right to make autonomous decisions about their participation in research, and their dignity and rights were respected throughout the research process. Researcher conducted research with honesty, integrity, and transparency, accurately reporting findings and acknowledging any conflicts of interest or biases.

*Cultural sensitivity and respect:* Researcher recognized and respect cultural diversity, values, beliefs, and practices, ensuring that research activities are conducted in a culturally sensitive and inclusive manner. The researcher was aware of and respect local customs, values, and norms in Lwanda sub-county. This involved adjusting the language or approach used in questionnaires and interviews to ensure they were culturally appropriate.

*Minimization of harm:* The researcher carefully considered any potential risks to participants, particularly when discussing sensitive issues on BCTB. These discussions could lead to

discomfort or anxiety, especially if participants fear repercussions.

Qualitative data was analysed through use of content analysis which involves systematically examining data to identify patterns, themes, and meanings within the content. Qualitative responses captured using interview guide was presented through reporting results in form of verbatim statements. Quantitative analysis was done using SPSS version 22.0 (Statistical Package for the Social Sciences) which involves a series of steps to manipulate data, run statistical tests, and interpret results and results were presented in tables and figures. Inferential statistics were also generated where T-tests determined whether there was a statistically significant difference in management practices of BCTB and coffee yields.

*Chi-Square test:* was done to examine the relationship between two categorical variables. For example, a chi-square test could assess whether there was an association between BCTB management practices and coffee yields. Correlation analysis was also done: this measured the strength and direction of the relationship between two numerical variables. For example, correlation analysis could examine the relationship between the study variables.

*The study limitations included:* access to respondents: certain key informants were difficult to access, resulting in incomplete data or reliance on less informed participants, which could affect the depth and accuracy of the study. To mitigate challenges in accessing key informants, the study utilized multiple data collection methods, including phone interviews, scheduled appointments, and the use of local contacts to facilitate access.

*Response bias:* Respondents provided socially desirable answers or may not be entirely honest in their responses due to fear of negative repercussions, especially if the study involved discussions on coffee yields. To reduce response bias, the researcher assured respondents of confidentiality and anonymity, emphasizing that their responses were only used for research purposes.

*Language barriers:* If the questionnaires or interviews were not conducted in a language familiar to all respondents, or if the terms used were not clearly understood, this could lead to misunderstandings or inaccurate responses. The study ensured that questionnaires and interviews were translated into the local language (for example., Luganda) and pre-tested for clarity. Trained research assistants who were fluent in both the local language were used to facilitate accurate communication.

*Limited access to sensitive information:* Due to confidentiality and privacy concerns, some industries might be unwilling to share detailed information on their coffee yields, limiting the depth of the data collected. Respondents were given the option to provide anonymous responses, and data collection was guided by ethical research standards, including obtaining informed consent before discussions.

*Limited time for data collection:* The study might be conducted over a limited period, which could restrict the amount of data that can be collected or the ability to revisit respondents for follow-up questions or clarifications. To maximize the efficiency of data collection within the available timeframe, the researcher employed well-structured data collection schedules and use multiple research assistants to cover a broader respondent base simultaneously.

*Resource limitations:* Insufficient resources to use may limit the ability to reach a wider sample, conduct more extensive fieldwork, or employ additional research staff, potentially affecting the study's comprehensiveness. To mitigate resource constraints, the study adopted a cost-effective sampling approach, such as purposive or simple random sampling, to ensure the most relevant respondents were included.

## 8. Study Results

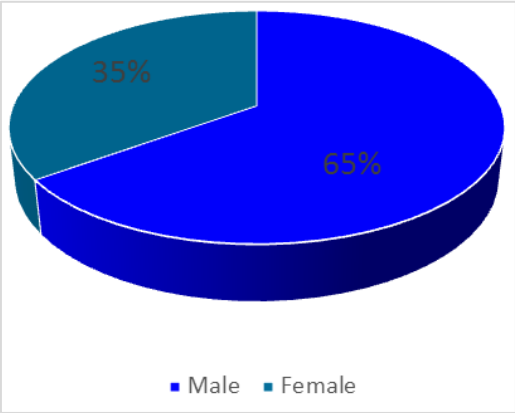



***Figure 2.*** *Gender of respondents.*

As shown in Figure 2, 65% of the respondents were males and 35% were female. The dominance of males in the study meant that Black Coffee Twig Borer (BCTB) management practices were hectic and could not be done by majority of females. However, the results implied that the study did not suffer from gender bias.

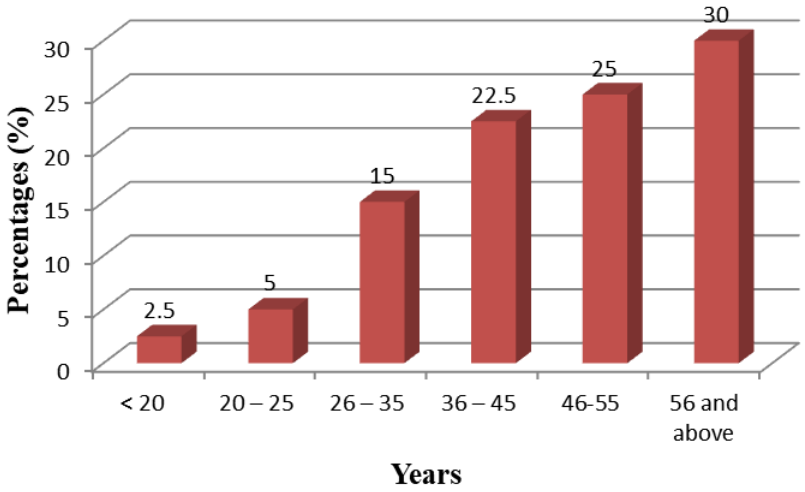



***Figure 3.*** *Age of the respondents.*

According to results in figure 3 farmers aged 26–35 constitutes to 15% These farmers are likely to have the highest yields, possibly due to greater physical energy, education, and access to agricultural extension services or technologies (like BCTB control methods. Younger groups (<20 and 20–25) constitutes to 2.5% and 5% respectively. This group shows slightly lower yields due to limited farming experience or access and control over resources despite their energy and openness to innovation. Farmers aged (36–45) constitutes to 22.5%. Farmers who belong to such age group may show stable or slightly declining yields, depending on how actively they adopt BCTB control practices. Older farmers (46–55 and >55) constitutes to 25% and 30% respectively. This group of farmers are likely to have lower yields, potentially due to limited labor to prune or scout for BCTB damage, less adoption of improved pest control methods and declining physical strength or less motivation to invest in intensive management.

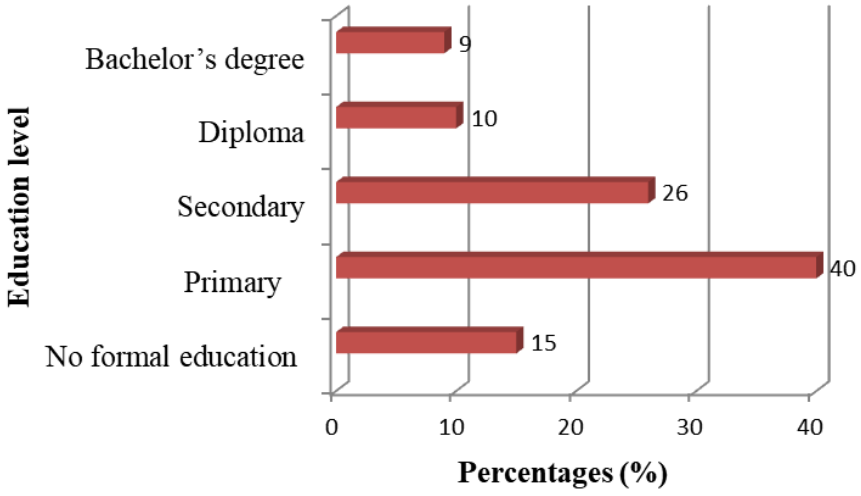



***Figure 4.*** *Level of education.*

The results in the figure 4, revealed that majority of the respondents completed primary education that constitutes to 40%, secondary education; 26%, no formal education; 15%, diploma holders; 10% and bachelor's degree holders; 9%.

With a total of 55% of the respondents having only primary or no formal education, a large segment of the popula-

tion may lack the technical knowledge or access to agricultural extension services to effectively identify and control BCTB. These farmers are less likely to adopt advanced pest control techniques or interpret extension messages and may rely on traditional methods, which may not be effective against BCTB, leading to higher yield losses. Secondary educated farmers representing 26%, this group may have a better understanding of extension messages and printed guides but may still lack practical exposure or resources to implement effective BCTB control measures fully. Higher Education (Diploma & Bachelor's) which totally constitute to Only 19% of respondents fall in this category. These individuals are more likely to understand and apply scientific information on BCTB management, access and utilize modern technologies and agrochemicals correctly and finally benefit from training and extension services more effectively, leading to better BCTB control and higher coffee yields.

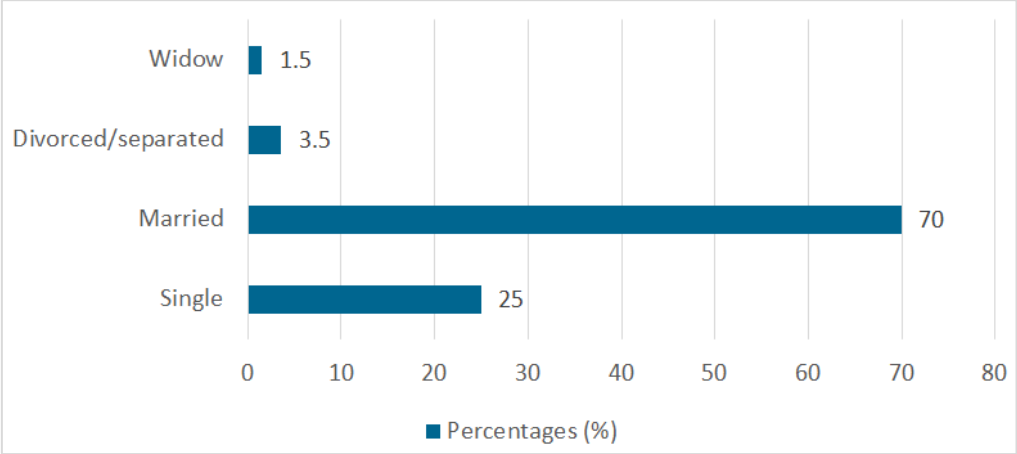



***Figure 5.*** *Marital status.*

According to the figure 5, Married farmers constitute the majority (70%). Married individuals may benefit from household labor, with spouses and children often contributing to farm activities. This positively influence coffee productivity, through facilitating long-term investment in farm improvements like soil fertility management and Black Coffee Twig Borer control. Single farmers account for 25%. While single farmers may be younger and more energetic, they might lack sufficient labor support or experience. This could result in less consistent yields if farming is part-time or not well-managed. Divorced/separated represent 3.5%. These groups experience labor shortages, emotional stress, or reduced financial resources, which could negatively impact coffee yields. They may also be more vulnerable to exploitation, land tenure issues, or exclusion from support programs, reducing their capacity to maintain or expand production.

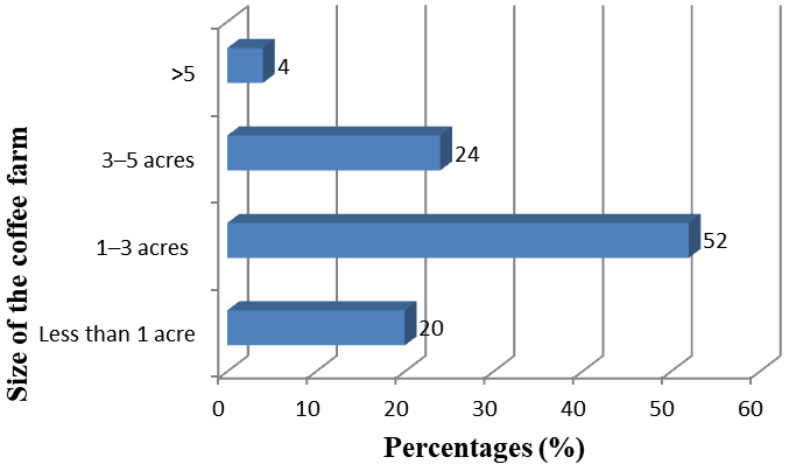



***Figure 6.*** *Size of coffee farm.*

The figure 6 shows the distribution of coffee farms based on their sizes and the corresponding percentages of farmers managing each size. 1–3 acres: The majority of farmers (52%) own coffee farms within this range. 3–5 acres: A significant portion (24%) of farmers have moderately larger farms. Less than 1 acre: 20% of farmers operate very small coffee farms. More than 5 acres: Only a small fraction (4%) own large-scale farms. Small farm sizes may restrict farmers from experimenting with new coffee varieties or implementing large-scale good agricultural practices, potentially limiting yields and quality. The results imply that coffee farming in the study area is predominantly a small-scale activity, with most farmers operating under 3 acres. This pattern has direct consequences on coffee yields, as smallholders often face challenges related to resource availability, technical know-how, and access to markets. Efforts to improve coffee productivity must therefore focus on equipping smallholder farmers with affordable and scalable innovations such as; efficient pest and disease control (for example., for coffee wilt and twig borer), improved coffee seedlings, post-harvest handling and value addition training and among others.

***Table 1.*** *Management practices used to control BCTB.*

| BCTB Practice | Mean Score | Std. Dev | t-value | p-value < 0.05 |
|---|---|---|---|---|
| Regular pruning | 4.2 | 0.9 | 25.64 | 0.000 |
| Removal & burning of infested twigs | 4.0 | 1.0 | 20.00 | 0.000 |
| Shade regulation | 3.5 | 1.1 | 9.09 | 0.001 |
| Timely harvesting | 3.8 | 0.95 | 16.84 | 0.003 |
| Use of parasitoid wasps | 2.9 | 1.3 | 2.35 | 0.125 |
| Other chemical control methods | 3.0 | 1.2 | 2.74 | 0.007 |

P-value < 0.05 shows significant effect

A low standard deviation shows that most farmers gave similar scores and therefore agreed that the practice is effective. A high standard deviation shows that farmers had mixed/different opinions where some thought it was very effective, others thought it was not. A high t-test means there is a strong difference between the observed mean and the neutral point where farmers clearly believe that the practice is effective. A low t-test means the difference is small the practice is not effective and leads to non significant effect.

The results in Table 1 show that regular pruning practice has the highest mean score 4.2, indicating it is widely adopted and perceived as highly effective by most farmers. The low standard deviation 0.9 shows a high level of agreement among respondents. The strong t-test and very low p-value =0.000 confirm that this result is statistically significant. An implication that regular pruning is a core BCTB management practice and is strongly accepted and implemented by farmers.

Removal & Burning of Infested Twigs as a practice has Mean Score: 4.0, Std. Dev: 1.0, t-test: 20.00 and p-value=0.000. This practice is also highly adopted and considered effective. It directly targets and reduces the BCTB population. The statistical results confirm that the practice is significantly favored among the respondents. the results imply that its a key method in BCTB control efforts and is strongly supported by coffee farmers.

Shade regulation has moderate average score of 3.5 which suggests that this practice is commonly used and seen as moderately effective. p-value =0.001 shows that it has statistical significant effect on BCTB control.

Timely harvesting shows Mean score of 3.8, Std. Dev: 0.95, t-test: 16.84 p-value =0.003. The results show that the practice is most preventative role in BCTB management.

The results show that release of parasitoid wasps has Mean score: 2.9, Std. Dev: 1.3, t-test: 2.35 and p-value: 0.125. Despite the p-value being below 0.05, it is marked as not significant, likely due to stricter criteria or lower power in the analysis. The lower mean score and high standard deviation suggest limited adoption and mixed perceptions towards its application. This implies that this biological control through parasitoid wasps is still emerging, with limited awareness, access, or confidence among farmers.

Other chemical control methods has Mean score: 3.0, Std. Dev: 1.2, t-test: 2.74 p-value =0.007. The average score of 3.0 shows moderate use, and the significance level (P-value) indicates that this practice is recognized but not dominant. It is used as a supplement or in emergencies when BCTB infestation is severe.

In an Interview conducted with key informants on role they think climate change or environmental conditions play in the severity of BCTB infestations and their impact on coffee yields, it was said that "*Warmer temperatures and prolonged dry spells favour BCTB multiplication. Also, changing rainfall patterns stress the plants, making them more*

*susceptible. Climate change is definitely making it harder to control BCTB effectively*".

In another interview conducted with the key informants on support or interventions necessary to mitigate the negative effects of BCTB on coffee yields in the future, it was reported that, "*We need more research into resistant coffee varieties, increased funding for extension services, and affordable pest control products. Government and NGOs should support awareness campaigns and subsidize pruning tools. Introducing integrated pest management programs at community level is critical*".

In another interview conducted with extension agents on how they collaborate with local leaders to ensure the successful implementation of BCTB management strategies, it was revealed that "*We hold community gatherings and involve local council chairperson and parish chiefs to mobilize farmers. Leaders help in setting bylaws on sanitation and coordinated action days where farmers work together on pest control. Their involvement gives weight to our interventions*".

Another interview was conducted with local leaders on the role local leadership plays in supporting coffee farmers to manage BCTB infestations, it was said that "*Local leaders act as the link between extension services and the farmers. They help us mobilize farmers, enforce collective action, and pass on key messages during community meetings. Their support is essential in overcoming resistance and ensuring community compliance*".

## 9. Discussion of Results

The study finding revealed that regular pruning has the highest mean score of 4.2 signifies that this agronomic practice is widely adopted and positively perceived by the majority of the smallholder coffee farmers. Respondents further explained that maintaining an optimal plant structure through pruning simplifies harvesting operations and other management tasks such as spraying, weeding, and fertilizer application. This reduces labor costs, increases harvest efficiency, and minimizes berry damage, which can indirectly affect coffee yield quantity and quality. This finding is in line with Mwangi et al., whose study reported that farmers rely heavily on regular pruning to remove infested twigs and branches. This practice is essential in reducing the pest's habitat and limiting its spread [13]. Mwangi et al., further explained that effectiveness of this practice is often hampered by inadequate training and the labor-intensive nature of the work [13].

The study results indicated that removal & Burning of infested Twigs as a practice was highly adopted and considered effective. Farmers further explained that this practice helps in directly reducing the population of the pest, minimizing its spread, and ultimately improving coffee yields. they however, reported that the removed twigs are immediately collected and burned. This destroys all life stages of the BCTB (adults, eggs, larvae, and pupae) that may still be inside the twigs. If the twigs are discarded carelessly, the borer may escape and infest other nearby trees. This finding can be compared with Musoli et al., who in their study reported Ugandan farmers primarily use this cultural practice to manage BCTB through removing and burning infested twigs to prevent the pest's spread [11]. Additionally, farmers are encouraged to maintain good field sanitation, though adherence varies due to resource constraints and varying levels of awareness.

The study results show that timely harvesting is an important cultural practice that helps control the Black Coffee Twig Borer (BCTB) and consequently improves coffee yields. Farmers further explained that when ripe berries are left on the tree, BCTB populations can spread to neighboring twigs and other plants. Timely removal of ripe cherries helps reduce pest movement to adjacent trees as this leads to healthier coffee plants and better flowering and fruiting in subsequent seasons. By removing the mature berries in time, the plant is relieved of this burden, allowing it to focus on new growth and recover faster from pest damage. This finding can be compared with Munyaneza et al., whose study carried out in Kenya emphasized that timely harvesting, combined with field hygiene, reduced BCTB infestation by more than 30% in smallholder coffee farms [10]. Munyaneza et al., observed that delay in cherry picking allowed the pest to move from older to newer twigs [10].

The results show that the use of natural predators like spiders and parasitoid wasps is a promising biological control strategy for managing the Black Coffee Twig Borer (BCTB) and improving coffee yields. Parasitoid wasps help reduce BCTB populations by naturally attacking and suppressing the pest, thereby minimizing damage to coffee trees and enhancing productivity. This finding can be compared with [2] whose study in United States and Australia, reported that biological control is a key component of BCTB management particularly use The use of natural predators such as parasitic wasps and entomopathogenic fungi which have been explored and implemented to reduce BCTB population.

The study results indicated that chemical control methods are among the strategies used to manage the Black Coffee Twig Borer (BCTB) and improve coffee yields, especially when infestation levels are high. These methods involve the application of insecticides that target different life stages of the pest to reduce their population, minimize crop damage, and allow the coffee plant to recover for optimal production. Farmers explained that contact insecticides kill BCTB adults and larvae upon direct exposure. These are usually sprayed on infested coffee twigs and branches. This finding is consistent with Black et al., who in their study established that while there is a growing emphasis on sustainable practices, chemical control remains a critical part of BCTB management in developed nations [1]. The same authors further reported that advanced pesticides that target BCTB without harming non-target organisms are frequently used.

## 10. Study Conclusion

The results indicate that most Black Coffee Twig Borer (BCTB) management practices, including regular pruning, removal and burning of infested twigs, shade regulation, timely harvesting, and other chemical control methods, had a statistically significant effect ($p < 0.05$) in managing the pest. Among these, regular pruning showed the highest effectiveness (Mean = 4.2, $p = 0.000$). However, the use of parasitoid wasps did not have a statistically significant effect ($p = 0.125$), concluding that it is a less consistently applied method among farmers.

## 11. Study Recommendations

Promote and scale up effective practices: Agricultural extension services and coffee development programs should prioritize and promote the adoption of highly effective BCTB control practices such as regular pruning, removal and burning of infested twigs, shade regulation, timely harvesting, and chemical control methods, given their significant impact on pest management.

Capacity building for farmers: Conduct targeted training and awareness campaigns to equip smallholder farmers with the knowledge and skills needed to implement the most effective BCTB control practices consistently and correctly.

Integrated Pest Management (IPM) approach: Encourage farmers to adopt a combination of effective practices under an IPM framework to achieve more sustainable and long-term control of BCTB.

Improve access to credit and financial services: Given the significant influence of credit services, financial institutions should design farmer-friendly loan products to support investment in pest control inputs.

Promote positive attitudes and awareness campaigns: Since farmer attitudes and perceptions significantly influence practice adoption, behavior change communication strategies should be implemented to raise awareness of the benefits of BCTB control.

Prioritize control of BCTB to prevent direct yield losses: Since berry drop was found to have the most significant impact, extension services and coffee sector stakeholders should focus on promoting timely and effective BCTB management to reduce direct yield losses.

Support cost-effective pest management: Given the significant income losses due to increased production costs and labour, there is a need to promote affordable and labor-saving BCTB control technologies, such as integrated pest management (IPM) strategies.

Monitor and address long-term market effects: Although reduced marketability and price reduction were not statistically significant, continued monitoring is recommended to assess potential long-term economic impacts and help farmers align with market demands.

Strengthen policy and institutional support: Policymakers should integrate BCTB control into national coffee development strategies, ensuring that affected farmers receive timely support through subsidies and training.

Enhance quality focused interventions: As BCTB significantly reduces coffee quality, farmers should be sensitized on quality-preserving practices, and supported with training and tools to maintain bean integrity and post-harvest standards.

## Abbreviations

| | |
|---|---|
| IPM | Integrated Pest Management |
| BCTB | Black Coffee Twig Borer |
| SPSS | Statistical Package for Social Scientists |
| NGOs | Non-governmental Organisations |

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## Author Contributions

Ssemusu Edwin conceptualized and designed the study, collected and analyzed the data, and drafted the manuscript. Tumusiime Bernard contributed to data curation, validation, and assisted in reviewing and editing the manuscript. Prof. Ssemakula Edward supervised the study, provided resources, guided project administration, and critically revised the manuscript. This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

## Conflicts of Interest

The authors declare no conflicts of interest.

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