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Incidence, Damage and Management of the Major Pests and Diseases of Robusta Coffee, [*Coffea canephora* (Pierre Ex A. Froehner)] in Uganda

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Abstract

Black Coffee Twig Borer (BCTB), *Xylosandrous compactus* Eichhoff (Coleoptera: Scolytidae) and Coffee Wilt Disease (CWD) are still the two main biological constraints to Robusta coffee production in Uganda. A rapid assessment survey was conducted in January 2022 in the Regions of Eastern (Busoga), Greater Masaka, Western, South western and Rwenzori to determine the status of pests and diseases in the different regions. A short-structured questionnaire with both open and closed-ended questions was administered to 268 participants that were purposively selected in different regions. At plot level, five coffee plants were selected in each of the sampled coffee farms for observation. The selected stems were checked for infestation by the stem borers and root mealy bugs (evidenced by ants moving up and down the coffee tree). The coffee canopy was divided into 2 imaginary sections—upper and lower to assess damage by leaf skeletonizers, tailed caterpillars, beetles, aphids, mealybugs, lygus, brown eye spot, coffee leaf rust, scales, aphids, berry moth and red blister. In addition, data was collected at field level parameters including: shade intensity, the most common shade trees, weed management and most common weeds (whether grasses, sedges or broadleaved), mulching intensity and mulching material, manuring intensity and common manure used, fertilizer application and type of fertilizer used, presence and type of cover crops, presence of bands and trenches as well as intensity of intercropping and the most common intercrops.

Field observations revealed that the Black Coffee Twig Borer (BCTB) was responsible for the drying up of young and old coffee branches across all regions together with Coffee Wilt disease (CWD) to a smaller extent. On average, 9.4% of the primary branches were infested by BCTB. The highest damage levels of BCTB were recorded in Eastern (17.2%) and Western (12.4%) regions. Although, BCTB affected all ages of coffee, young coffee of 2-3 years was most affected. Overall, 3.9% of the sampled coffee trees were infected by Coffee Wilt Disease (CWD), with the highest incidence (8.2%) recorded in Southwestern Uganda.

There is need to enhance existing management measures for coffee pests and diseases especially BCTB and CWD. Due to the high levels of spread of BCTB, this will require a community approach to sensitize farmers through meetings and media on the sustainable management of BCTB. There is also need to come up with good dissemination strategies of Coffee Wilt Disease Resistant varieties to aid their uptake and roll out a gap filling programme for coffee trees infected and destroyed by CWD across all regions using CWDr varieties.

Keywords: coffee, Black Coffee Twig Borer (BCTB), skeletonizers, Coffee Wilt Disease (CWD), Red Blister Disease (RBD), Coffee Leaf Rust (CLR)

1. Introduction

Coffee is one of the top-traded agricultural commodities in the world, generating substantial gross revenues annually and contributing critically to the gross domestic product of coffee- producing countries such as Uganda

(ICO, 2019). Uganda is the second largest producer after Ethiopia and leading exporter of coffee in Africa (FAO, 2019). Coffee is one of the main cash crops in Uganda, playing a role in providing foreign exchange (NCP, 2013). For example, coffee exports for 12 months (March 2023-February 2024) totaled 6.06 million 60 kg bags worth USD 980 million (UCDA, 2024). The crop is grown on an estimated 353,907 hectares of land by about 1.7 million smallholder farmers (a quarter of them being female-headed) and 90% of these smallholder farmers owning gardens ranging between 0.5 and 2.5 hectares in size (Hill, 2005; NCP, 2013; Mugoya, 2018).

There are two important types of coffee that are grown in Uganda with Robusta coffee constituting over 80% whereas Arabica constitutes 20% of the total coffee produced and exported (UCDA, 2019). More than 9 million people in Uganda derive their livelihood from coffee-related activities along the value chain (NCP, 2013). It therefore, has a very high employment potential and poverty reduction effect on the smallholder farming households (Mbowa et al., 2014). Being a perennial crop and due to its morphological and floristic structures, it also plays many other important ecological roles including conservation of useful flora and fauna such as pollinators and decomposers as well as the ecological services they mediate (Rappole et al., 2003). It also reduces atmospheric carbon dioxide concentration through the integration of agroforestry trees that help in carbon sequestration (Polzot, 2004). Coffee is therefore a key commodity contributing to the 1st, 2nd and 13th Sustainable Development Goals (SDGs) of 'No Poverty', 'Zero Hunger' and 'Climate Action' (https://sdgs.un.org/goals). The Government of Uganda National Development Plant III (NDP III) therefore prioritizes coffee as one of the six commodities for value addition for increased household incomes, exports earnings and import replacement (NPA, 2020).

However, despite the importance of the crop to the farmers and the nation at large, its production and productivity in Uganda is still below the attainable yields of about 2.2t ha^{-1} (Wang et al., 2015). The actual clean (green) Robusta coffee yields average at 0.6 t ha^{-1} and this is far below the potential yields of 2.2 t ha^{-1} (Van Asten et al., 2011) or the yield of 4.8 t ha^{-1} of the improved KR10, one of the CWDr varieties (Musoli et al., 2017). This low productivity has been attributed to a number of constraints, with the outbreaks and resurgences of pests and diseases, particularly, the Black Coffee Twig Borer (BCTB), Coffee Wilt Disease (CWD), and Red Blister Disease (RBD) being paramount (Adipala et al., 2001; Egonyu et al., 2009; Kagezi et al., 2013). Black Coffee twig borer alone contributes to 9% of yield loses whereas coffee wilt disease can result into 100% yield loses in susceptible Robusta lines (Kagezi et al., 2016a). There is therefore, a need for regular monitoring, surveillance and updating of the status of the pests and disease in the Robusta coffee growing regions of Uganda (Peck & Boa, 2023). This is vital for informing timely and effective response to pest situations and making the right decisions for managing pests and diseases (Kansiime et al., 2017). Thus, a rapid assessment survey was conducted in the five major Robusta coffee growing regions of Uganda with the main aim of establishing the status of pests and diseases of Robusta coffee, socio-economic characteristics and farmers' copying mechanisms.

2. Methodology

The rapid assessment survey was conducted in the major Robusta coffee growing Regions of Eastern (Busoga), Greater Masaka, Western, South western and Rwenzori. Four districts were surveyed per region; Busoga (Iganga, Kamuli, Bugiri, Namutumba), Greater Masaka (Lwengo, Lyantonde, Rakai, Sembabule), South Western (Bushenyi, Sheema, Mitooma, Buhweju), Rwenzori (Kabarole, Kyegegwa, Kyenjojo, Kamwenge), Western (Mubende, Kassanda, Masindi, Hoima).

Ten (10) coffee growing households from two sub counties in each district were purposively selected and used for this study. A short-structured questionnaire with both open and closed-ended questions was administered to a sample of 268 households. The questionnaire was eliciting farmers' knowledge on the various factors; biotic, abiotic and socio-economic factors hindering coffee production in the region as well as the available coping mechanism.

At plot level, five coffee plants were selected in each of the sampled coffee farms. On each coffee plant, at least three stems were randomly selected for data collection. The selected stems were checked for infestation by the stem borers (evidenced by the entry holes and frass on the ground) and root mealy bugs (evidenced by ants moving up and down the coffee tree). The number of primary branches on each stem and those infested BCTB (evidenced by the entry hole and wilting or drying of coffee twigs) were established and used to compute the percentage infestation. The coffee canopy was divided into 2 imaginary sections—upper and lower. One primary branch was randomly picked in each of the section and the number of leaves as well as those damaged by leaf skeletonizers, tailed caterpillars, beetles, aphids, mealybugs, lygus, brown eye spot and coffee leaf rust were established. The number of clusters on each selected primary branch and those damaged with the canopy mealybugs, scales, aphids, berry moth, red blister were established. One cluster was picked from the selected

clusters and the number of berries damaged by the coffee berry borer, coffee berry moth and red blister was established. The disease scale of; 1 = no disease, 2 = less than 25% disease, 3 = 26 to 50 % disease, 4 = 51 to 75% disease, and 5 = more than 75% disease was adopted to assess disease severity for red blister, coffee leaf rust, and brown eye spot on each coffee plants.

In addition, data was collected at field level parameters including: shade intensity and the most common shade trees, weed management intensity and most common weeds (whether grasses, sedges or broadleaved), mulching intensity and mulching material, manuring intensity and common manure used, fertilizer application and type of fertilizer used, presence and type of cover crops, presence of bands and trenches as well as intensity of intercropping and the most common intercrops.

2.1 Data Analysis

Descriptive and summary statistics such as means, frequencies and variances were used to analyze the data using SPSS version 22 software.

3. Results and Discussions

3.1 Demographic Characteristics of the Study Sample

The demographic characteristics of the households interviewed in major Robusta coffee growing regions of Uganda are summarized in Table 1. Out of 268 households that were interviewed, majority (86%) of the respondents were household heads. This implies that most of them were decision makers of the households and were informed about their coffee farms. Similarly, Luzinda et al. (2015) also reported the same findings in his study. In terms of the sex of the respondents, the majority (92%) of the respondents were males and (8%) were female. This indicates that coffee growing in Uganda is male dominated and the males are key decision makers on how the money obtained from coffee sales is utilized. This finding agrees with other similar studies conducted in coffee agro-systems of Uganda (Kagezi et al., 2018, 2021) and in other developing countries (Ncube et al., 2011; Lekei et al., 2014; Akiri et al., 2015). This gender inequality is likely to demoralize female farmers from actively engaging in coffee farming activity, thus impacting negatively on coffee production since women are key in farm operations (Ngeywo et al., 2015). The average age of the interviewed was 53 years, with a range of 23 to 84 years, agreeing with studies in Uganda (Mbowa et al., 2014; Kagezi et al., 2018, 2021) and elsewhere (Ngeywo et al., 2015). This implies that few youth are involved in coffee growing and could negatively impact on the sustainability of coffee growing in the long run. Relatedly, similar findings have been reported by other authors such as Mbowa et al.(2013) and Ngeywo et al. (2015). The limited involvement of female and youth in coffee farming can be attributed to land tenure system where women and the youth do not have rights of ownership to land. Similarly, youth and women are financially constrained hence they cannot purchase land and inputs such as fertilizers and pesticides that are required in coffee farming. This calls for creation of programs and initiatives by both public and private sectors that attract the youth and women to engage in coffee production (Kitakaya, 2011; Mbowa et al., 2014; Kagezi et al., 2021).

Younger farmers are usually more dynamic in the adoption of new production technologies, while older ones tend to avoid technologies that demand for energy (Ngeywo et al., 2015; Kagezi et al., 2021). Furthermore, most (50%) of the interviewed farmers had completed primary education, 25% completed O' level and 4% degree level. These findings are in line with the findings of other studies in the coffee agrosystems of Uganda (Kitakaya, 2011; Kagezi et al., 2018) and other developing countries (Lekei et al., 2014). Educational level of the farmers has a profound effect on their ability to adopt new technologies as more educated farmers can easily learn and adopt new technologies compared to their counterparts (Mugisha et al., 2004) since the latter can easily synthesize information availed and apply it to farming (Lin, 1991).

Table 1. Household characteristics of interviewed coffee farmers in the major Robusta coffee growing regions of Uganda

	Number	Percentage respondents (%)
Household head status		
Yes	230	86
No	38	14
Gender		
Female	22	8.2
Male	246	91.8
Marital status		
Married	245	91.4
Widowed	10	3.7
Single	7	2.6
Separated	6	2.2
Education level		
No formal education	25	9.3
Primary	131	48.9
O' level	68	25.4
A' level	11	4.1
Certificate	11	4.1
Diploma	12	4.5
Degree	10	3.7
Primary source of income		
Crop production	246	91.8
Trading	12	4.5
Formal employment	8	3.0
Animal rearing	2	0.7
Standard error		0.752
Standard deviation		12.31
Sample variance		151.55

Source: Primary data.

The survey findings also revealed that majority (92%) of the respondents obtained their income from crop production while, less than 5% of them obtained their income from formal employment, trade and animal rearing. This finding is in agreement with several authors who have reported that majority of farmers in Uganda derive their livelihood from crop production (McDonagh and Bahiigwa, 2002; Nabuuma et al., 2021). Furthermore, Table 2 summarizes the major cash crops grown by the interviewed households. Most (86%) farmers mentioned coffee as their main cash crop, as also reported in the various coffee agrosystems surveys in Uganda (Bongers et al., 2015; Maate and Nyamweha, 2021). At regional level, the highest percentage of farmers who mentioned coffee as their main cash crop was recorded in Greater Masaka (97%), followed by Southwestern (96%) and then Rwenzori region (95%). This finding confirms Greater Masaka as the largest producer of Robusta coffee in Uganda as reported earlier by Cheyns et al. (2006).

Table 2. Major cash crop grown in the sampled households in the main Robusta coffee regions of Uganda

Crop	Coffee growing region (%)					
	Busoga	Greater Masaka	Rwenzori	Southwestern	Western	Mean
Coffee	81	97	95	96	61	86
Maize	9	2	3	0	13	5.4
Banana	2	2	0	3	9	3.2
Others	4	0	2	1	4	2.2
Rice	5	0	0	0	4	1.8
Beans	0	0	0	0	9	1.8

Source: Primary data.

3.2 Insect Pests Infesting Robusta Coffee

3.2.1 Farmers' Knowledge of the Insect Pests They Encountered on Their Robusta Coffee in the Last Two Years

Farmers in the major Robusta coffee growing regions of Uganda mentioned eight insect pests they had encountered on their coffee in the last two years (Table 3). These included: Black Coffee Twig Borer (BCTB), *Xylosandrus compactus* (Eichhoff), tailed caterpillar, *Epicampoptera andersoni* (Tams), leaf skeletonizers, *Leucoplema dohertyi* (Warren), root and canopy mealybugs, *Planococcus* spp., Coffee Berry Borer (CBB), *Hypothenemus hampei* (Ferrari), scales, *Coccus* spp. and biting ants. Most (15.8%) of the respondents indicated BCTB (15.8%) as the most common pest they have encountered in the last 2 years. At regional level, the highest number of farmers who reported BCTB as the main pest was recorded in southwestern region (23%), followed by Greater Masaka (17.0%) and western (15.0%). Our findings are in line with other earlier studies that have indicated that farmers have reported BCTB as the most important insect pest infesting Robusta coffee in Uganda (Egonyu et al., 2009; Kagezi et al., 2015; Kobusinge et al., 2018). Damage by this pest is easily recognized by the farmers because of the characteristic entry hole it makes on the attacked host plant part (Greco & Wright, 2015; Kobusinge et al., 2018) and its distinct symptoms of yellowing of the leaves and drying and death of attacked plant part (Greco & Wright, 2015; Kobusingye et al., 2018).

Table 3. Pests encountered by farmers (%) on coffee in the last two years across the Robusta coffee growing regions of Uganda

Pest	Region (%)					
	Busoga	Greater Masaka	Rwenzori	Southwestern	Western	Mean
Black Coffee Twig Borer	13.0	17.0	11.0	23.0	15.0	15.8
Tailed caterpillar	2.0	0.0	2.0	2.0	3.0	1.8
Skeletonizers	2.0	0.0	2.0	0.0	1.0	1.0
Root mealybugs	0.0	1.0	1.0	1.0	2.0	1.0
Coffee Berry Borer	1.0	0.0	0.0	1.0	0.0	0.4
Scales	0.0	0.3	0.3	0.3	0.3	0.2
Canopy mealybugs	0.3	0.3	0.0	0.0	0.0	0.1
Biting ants	0.3	0.0	0.0	0.0	0.3	0.1

In addition, results of this study further showed that farmers were using various options to manage insect pests of coffee in the major Robusta coffee growing regions of Uganda (Figure 1). Majority (60%) of the farmers were using cultural methods (*e.g.*, cutting off and burning the damaged plant part, pruning, de-suckering, stumping/change of cycle, *etc.*). Our results are in agreement with various reports which showed that farmers in Uganda rely on cultural practices to control most of the insect pests of coffee (Kansiime et al., 2017). This method has been particularly useful for managing BCTB in Uganda (Egonyu et al., 2009; Kagezi et al., 2013, 2016a) and elsewhere (Jones & Johnson, 1996; Smith, 2003; Burbano, 2010; Greco & Wright, 2015). In fact, the National Agricultural Research Organisation (NARO) has developed a package based on cultural practices for managing this insect pest (Kagezi et al., 2016c). This package has proven effective where farmers use it properly (Kagezi et al., 2016b) and also, mathematical models have showed that these approaches can completely eliminate BCTB from farmers' fields (Ssembatya, 2017). The package is currently being scaled out by NARO,

Uganda Coffee Development Authority (UCDA), Local Government extension officers as well as other private sector. However, these cultural methods are labor intensive, tedious and need a community-based approach in order to be effective (Greco & Wright, 2015; Kagezi et al., 2016a). This, therefore calls for awareness campaigns and trainings in Integrated Pest Management (IPM) of this pest to be rolled out in this region (Kagezi et al., 2013; Aristizábal et al., 2017).

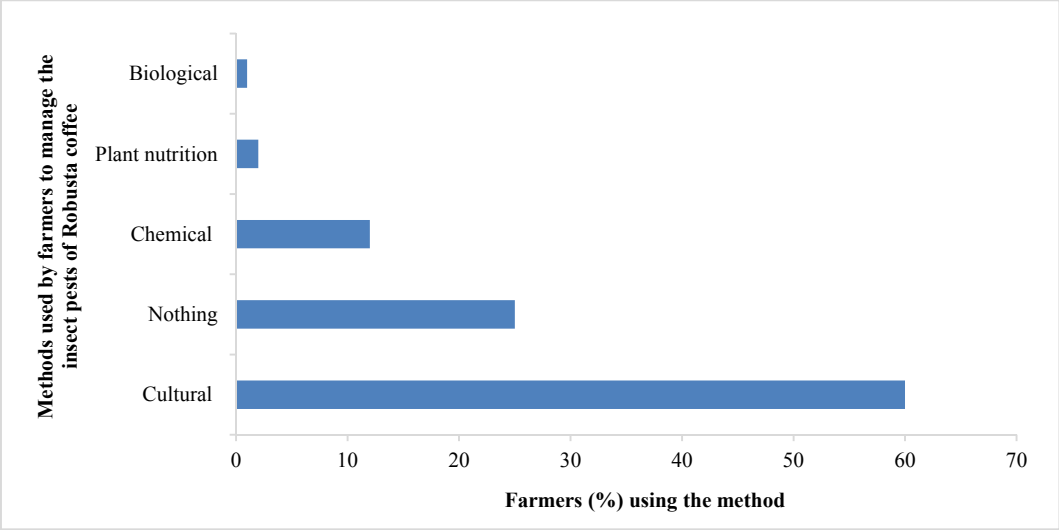

Figure 2. Methods used by farmers (%) to manage insect pests in the major Robusta coffee growing regions of Uganda

3.2.2 Incidence and Damage of Pests Infesting Robusta Coffee Primary Branches

Table 4 below summarizes the results of the field observation of primary branches that were infested by BCTB in the major Robusta coffee growing regions of Uganda. Results showed that on average, 9.4% of the primary branches were infested by BCTB. This finding is in line with a similar survey conducted in the Robusta coffee growing regions of Uganda in 2016 by Kagezi et al. (2016d). The BCTB infested all ages of coffee but mostly coffee of 2-3 years. Similarly, Arsi et al. (2023) recorded the highest percentage of BCTB attacks on young coffee plants found in mixed-aged coffee plantations, because young coffee plants have soft plant organs. At regional level, the highest BCTB infestation was recorded in Busoga (17.2%) and Western regions (12.4%). Similarly, Kagezi et al. (2016c) also observed the highest damage by BCTB in Busoga region, though it has generally increased from 14.4 to 17.2%. This finding agrees with reports from the UCDA extension teams based in the region as well as reports in newspapers. This could be in part due to limited knowledge of farmers of managing this insect pest. A survey conducted by Kagezi et al. (2013) reported that only 35% of the farmers in Busoga had knowledge of management options of this insect pest. This implies that BCTB is still a major challenge to Robusta coffee growing in Uganda (Egonyu et al., 2009; Kagezi et al., 2013; Kagezi et al., 2016a, 2016b, 2016d).

Table 4. Percentage of primary branches infested by the Black coffee twig borer (BCTB) in the major Robusta coffee growing regions of Uganda

Region	Percentage
Busoga	17.2
Rwenzori	7.1
Southern	2.0
Western	12.4
Mean	9.4

3.2.3 Incidence and Damage of Insect Pests Infesting Robusta Coffee Leaves

Six (6) insect pests including coffee leaf miners, *Leucoptera coffeella* (Guérin-Mèneville & Perrottet); leaf skeletonizers, *Leucoplema dohertyi* (Warren); tailed caterpillars, *Epicampoptera andersoni* (Tams); canopy mealybugs, *Planococcus* spp.; scales, *Coccus* spp.; and leaf eating beetles (Table 5) were observed in coffee gardens. On average, the highest damage (31.9%) was observed to have been caused by the tailed caterpillar, followed by leaf skeletonizers (12.5%). In Uganda, tailed caterpillar is generally considered as minor pest (Musoli et al., 2001) but, serious outbreaks have been recently reported in the districts of Kayunga and Luwero in 2017 (NaCORI/UCDA, 2017) as well as Masindi district in 2020 (NaCORI/UCDA, 2020). This insect pest attacks both Robusta and Arabica coffee and in large numbers and can cause a lot of defoliation of the coffee leaves, particularly for coffee neighboring forested areas (Waller et al., 2007).

Table 5. Percentage of coffee leaves infested by the various insect pests observed in the diverse Robusta coffee growing regions of Uganda

Region	CLM	LS	TC	LEB	CMB	SC
Busoga	5.2	15.8	24.3	7.9	0.1	0.4
Rwenzori	4.3	9.5	37.5	10.5	0.2	0.3
Southwestern	7.7	10.1	28.7	6.6	0.5	0.2
Western	2.9	15.6	37.0	8.6	0.3	0.0
National mean	5.1	12.5	31.9	8.5	0.3	0.2

Note. CLM = Coffee leaf miners; LS = Leaf skeletonizers; TC = Tailed caterpillars; LEB = Leaf eating beetles; CMB = Canopy mealybugs; SC = Scales.

3.2.4 Incidence and Damage of Insect Pests Infesting Robusta Coffee Berry Clusters and Berries

In addition, four (4) insect pests including: the canopy mealybugs, scales, Coffee Berry Moth (CBM), *Prophantis smaragdina* (Butler) (Lepidoptera: Pyralidae) and Coffee Berry Borers (CBB) were observed on the coffee berry clusters (Table 6). On the other hand, CBM and CBB were the only insect pests recorded on coffee berries (Table 7) in the major Robusta coffee growing regions of Uganda. Results showed that the highest infestation on coffee berry clusters (10.5%) and berries (7.8%) was caused by CBM, Similarly, Kagezi et al. (2021, 2023) reported that 31.2 and 12.6% of the coffee berry clusters and berries (respectively) of Robusta coffee trees sampled in Kaweri Coffee Plantation Ltd, central Uganda were infested by CBM. This insect pest has been existing since the 1940s' but it has just gained importance in Uganda and elsewhere (Mendesi and Tesfaye, 2009; Mugo et al., 2011; Gaitán et al., 2015; Liebig, 2017; Kagezi et al., 2021, 2023). Damage by CBM is initiated by the female moth laying eggs individually on the green berries and on hatching, they penetrate and feed on the berries where they complete their development (Barrera, 2017). Typical symptoms of attack include berry clusters in which the berries are webbed together and one or more is brown, dry or hollow (Gaitán et al., 2015). This damage may sometimes lead to secondary infection by the Coffee Berry Disease (CBD) fungus, *Colletotrichum kahawae* (Waller & Bridge) (Mendesil & Tesfaye, 2009).

On the other hand, 4.1% and 2.4% of the berry clusters and berries respectively were infested by CBB. However, the percentage of damaged coffee berries recorded in this study is far less than the 19.9% observed in a similar study conducted in 2016 (Kagezi et al., 2016d). This could be partly because by the time this study was conducted, the berries were in most cases few and still young. Field and laboratory studies indicate that factors such as berry ripeness and color play an important role on the susceptibility of coffee berries to CBB infestation, with a CBB preference for red and black berries (Gutierrez et al., 1998; Vega et al., 2009). Nevertheless, CBB still remains one of the most important insect pests infesting coffee berry clusters and berries in Uganda.

Generally, the damages caused by these pests and any other biotic challenges on the coffee berries is economically important since the berries are the final coffee product for consumption and market. These biotic stresses therefore reduce both yield and quality of coffee, which in turn affects the income of coffee growers (Damon, 2000; Jaramillo et al., 2006). This therefore calls for development of IPM strategies to manage these biotic stresses (Waller et al., 2007; Kagezi et al., 2022).

Table 6. Percentage of coffee berry clusters infested by the various insect pests observed in the diverse Robusta coffee growing regions of Uganda

Region	Canopy mealybugs	Scales	Coffee berry moth	Coffee berry borer
Busoga	4.8	0.9	14.8	5.6
Rwenzori	5.9	0.7	11.0	3.2
Southwestern	6.1	0.1	6.7	2.6
Western	6.7	0.9	11.0	6.3
National mean	5.9	0.6	10.5	4.1

Table 7. Percentage of coffee berries infested by the various insect pests observed in the diverse Robusta coffee growing regions of Uganda

Region	Coffee berry moth	Coffee berry borer
Busoga	8.3	2.1
Rwenzori	8.2	2.2
Southwestern	7.4	2.0
Bunyoro	7.2	3.7
National mean	7.8	2.4

3.2.5 Incidence and Damage of Other Insect Pests Observed on Coffee Trees

In addition to the insect pests observed on the coffee primary branches, leaves, berry clusters and berries, we also recorded three other insect pests including the root mealybugs, *Planoccocus* spp., lygus bugs, *Lygus* spp. and white stem borers, *Monochamus leuconotus* (Table 8). Results showed that 34.8% of the Robusta coffee trees sampled were infested by the root mealybugs, with the highest infestation (53.1%) being recorded in southwestern region. Kyamanywa et al. (2006) reported root mealybug infestation of 33.4% on Arabica coffee in the lowlands of Mt Elgon region, eastern Uganda. A recent survey by NaCORI and UCDA in central Uganda also reported that 11.1% of the trees they sampled had been infested by this pest (NaCORI/NARO, 2020). Root mealybugs are important pests of Robusta coffee in Uganda (NaCORI/UCDA, 2020), East African region (Rutherford & Phiri, 2006; Magina et al., 2016) as well as the other coffee producing countries in the world (Santa-Cecília & Silva, 2020; Borgh et al., 2021). Root mealybugs are usually congregated at lateral and main root junctions where they suck sap leading to slow growth, stunting, yellowing and loss of vigor of the coffee plant. Heavy infestation causes the plant to rot, and eventually saplings to die. After sucking sap, mealybugs on the root secrete honey dew which later results in the production of fungus (*Diacanthodes* sp.) and hinders nutrient absorption (Acevedo et al., 2020; Reddy et al., 2020). Serious infestations of this insect pest are often found where there has been use of insecticide sprays, especially highly toxic Organophosphate sprays (Fletcher, 2008).

Table 8. Percentage of coffee trees infested by the various insect pests in the diverse Robusta coffee growing regions of Uganda

Region	Root mealybugs	Lygus	Stem borers
Busoga	34.4	7.1	0.5
Rwenzori	31.7	5.4	0.0
Southwestern	53.1	2.1	0.0
Western	20.1	3,3	1.4
National mean	34.8	4.5	0.5

3.3 Diseases Infecting Robusta Coffee

3.3.1 Farmers' Knowledge of Robusta Coffee Diseases and Their Management Options

Farmers in the major Robusta coffee growing regions of Uganda mentioned five (5) diseases they had encountered on their coffee in the last two years (Table 9). All the diseases were caused by fungi and they included Coffee Wilt Disease (CWD) caused by *Fusarium xylarioides*, Brown Eye Spot (BES) and Red Blister Disease (RBD) caused by *Cercospora coffeicola*, Coffee Leaf Rust (CLR) caused by *Hemileia vastatrix* as well

as hot and cold disease, a disorder due to high day and very low night temperatures. Results showed that majority (15.2%) of the farmers indicated CWD as the most common disease they had encountered in the last two years. At regional level, the highest number of farmers who reported CWD as the main disease were recorded in southwestern region (25%), followed by Greater Masaka (17.0%) and western (13.0%). Similarly, Kobusinge et al. (2018) reported that majority of the farmers (70) interviewed in Busoga region mentioned CWD as the most important disease that was damaging their Robusta coffee. CWD has been the main disease of Robusta coffee since its advent in 1993 (Adipala-Ekwamu et al., 2001). By 2006, the disease had killed > 50% of the Robusta coffee in Uganda, causing a loss of 1.2 million bags, translating to a loss of US$100 million (Hakiza et al., 2009; Musebe et al., 2009). This undermined Government effort to increase coffee production from 3.15 to 12 million 60 kg bags by 2007/8 (UCDA, 2008/9). As for BCTB, farmers are also able to easily recognize a plant infected with CWD because of its distinct symptoms of complete wilting of the plant (Rutherford, 2006).

Table 9. Diseases encountered by farmers (%) on coffee in the last two years across the Robusta coffee growing regions of Uganda

Disease	Region (%)					
	Busoga	Greater Masaka	Rwenzori	Southwestern	Western	Mean
Coffee wilt disease (CWD)	10.0	17.0	11.0	25.0	13.0	15.2
Red blister disease (RBD)	7.0	1.0	5.0	0.0	1.0	2.8
Brown Eye Spot (BES)	1.0	0.0	0.0	0.0	2.0	0.6
Coffee Leaf Rust (CLR)	0.0	0.0	2.0	1.0	2.0	1.0
Hot and cold disease	0.0	0.0	0.3	0.3	0.0	0.1

On the other hand, farmers were employing a number of options to manage the diseases on coffee in the major Robusta coffee growing regions of Uganda (Table 10). Most (11.8%) of the farmers were using cultural methods to manage the diseases on Robusta coffee. The cultural options included: cutting and burning the infected plant material, uprooting and burning the infected plant, uprooting and not burning the infected plant, pruning, de-suckering, stumping or change of cycle, soil and water conservation, weed management, among others. Our finding is in agreement with studies by Luzinda et al. (2015), Kagezi et al. (2016a), and Kobusinge et al. (2018) that showed that majority of the farmers in Uganda usually employ cultural methods to manage Robusta coffee diseases, particularly CWD. Similarly, cultural methods are commonly employed by farmers in other coffee growing countries for the management of coffee diseases. Cultural methods for managing plant diseases are cheap, readily available and do not require many skills to implement them (Rutherford and Phiri, 2006). However, cultural practices are generally labor intensive, may be uneconomical and to be effective, they require to be applied at community level in order to reduce re-infection or infection from non-managing neighboring farmers (Rutherford & Phiri, 2006; Kobusinge et al., 2018).

Table 10. Options used by farmers (%) to manage coffee diseases in the major Robusta coffee growing regions of Uganda

Options	Region (%)					
	Busoga	Greater Masaka	Rwenzori	Southwestern	Western	Mean
Cultural	4.4	16.5	7.4	21.3	9.5	11.8
Nothing	12.5	2.7	9.1	5.4	7.4	7.4
Chemical	0.0	0.3	2.0	0.0	0.3	0.5
Biological	0.0	0.0	0.0	0.3	0.3	0.1
Plant nutrition	0.0	0.3	0.3	0.0	0.0	0.1

3.3.2 Incidence of the Main Diseases Infecting Robusta Coffee

Field observations showed that on average, 3.7% of the sampled coffee trees were infected by CWD, with the highest incidence (8.2%) being recorded in Southwestern Uganda (Table 11). This incidence is higher than the national average of 2.2 and 2.5% observed in the Robusta coffee regions in 2016 by Kagezi et al. (2016a) and in central Uganda by NaCORI/UCDA (2020), respectively. The results of this study imply that the disease is resurging in the country and this agrees with reports from various UCDA Regional Extension Officers and

Newspaper articles (New Vision, 2001, 2007, 2008; Daily Monitor, 2015). This could be attributed to the massive distribution and planting of elite coffee seedlings which are highly susceptible to CWD (UCDA, 2018; Ssempijja, 2021). There is therefore a need to develop effective strategies for limiting the spread of the disease to new areas while at the same time, managing it in areas where it already exists (Kansiime et al., 2017; Wassie, 2019).

Table 11. Percentage of coffee trees infected with Coffee Wilt Disease (CWD) in the major Robusta coffee growing regions of Uganda

Region	Incidence (%)
Bunyoro	2.5
Busoga	1.1
Rwenzori	3.1
Southwestern	8.2
National mean	3.7

3.3.3 Incidence and Severity of Other Diseases Infecting Robusta Coffee

Table 12 shows the incidence and severity of BES, RBD and CLR observed on coffee in the major Robusta coffee growing regions of Uganda. Results showed that on average, BES was recorded on 30% of the coffee trees sampled, with a severity of 1.2. However, these values are less than the incidence of 64.5% and severity of 1.5 reported in 2016 by Kagezi et al. (2016a) and recently (2020), the incidence of 47% and severity of 1.5 observed in central coffee growing region of Uganda (NaCORI/UCDA, 2020). At regional level, he highest incidence (77%) and severity (1.6) were recorded in Southwestern region and these values were more than those recorded in 2016 by Kagezi et al. (2016b) of 3% and 1.0, respectively This implies that the incidence and severity of BES is increasing in the region. BES symptoms appear on the leaves as necrotic spots with light-colored centers that are surrounded by a purplish-brown ring with yellowish edges (Souza et al., 2015). The affected leaves fall rapidly and the branches dry, causing a reduction in plant productivity and lowering the fruit's quality (Nelson, 1988; Ventura et al., 2007). In the absence of management measures for the BES, losses in coffee may reach up to 30% (Ramos et al., 2022).

On the other hand, 14% of the coffee trees sampled were infected by RBD which is caused by the same pathogen as BES, with an average severity of 1.2. These values are less than the incidence of 32.2 and severity of 1.4 observed at national level in 2016 by Kagezi et al. (2016c). They are also far less than the incidence of 51.5% and severity of 1.9 recorded recently in the central coffee growing region of Uganda (NaCORI/UCDA, 2020). At regional level, Southwestern region registered the highest incidence of 25.5% and severity of 1.2. This incidence is higher than the 18.3% observed in 2016 by Kagezi et al. (2016d). This implies that the disease is increasing in this region, as also reported in various UCDA reports (2022, 2023). Damage by RBD is characterized by reddish-dark brown patchy lesions that develop on berries ('berry blotch') and/or small red spots ('red blister') appearing on green or ripening berries (Rutherford & Phiri, 2006). Basing on this background therefore, research and extension should aim at reducing the spread of this important disease within and between coffee gardens as well as managing it in coffee gardens where it is already present.

Furthermore, on average 23% of the coffee trees assessed had been infected by CLR, with a mean severity of 1.3. The incidence and severity in our study are comparable to those observed in central Uganda coffee growing region of 32% and 1.5, respectively (NaCORI/UCDA, 2020). At regional level, the highest incidence (61%) and severity (1.3) were recorded in the Southwestern region. CLR manifests itself as yellow pustules on the lower surface of leaves turning orange-yellow with powdery masses of uredeniospores in later stages (Arneson, 2000). Defoliation of affected plants is a common symptom, which leads to loss of yield and quality of coffee (Rutherford & Phiri, 2006; Avelino et al., 2004). Therefore, our finding implies that on average, the coffee trees are losing 7.4% of their leaves, if the disease is not controlled (Avelino et al., 2004). CLR attacks both Arabica and Robusta coffee varieties, though the former is more susceptible and higher incidence and severity has been reported in the major Arabica coffee growing regions of Uganda (Matovu et al., 2013). The disease has been reported to cause about 10-50% yield loss in farms with susceptible coffee varieties especially if no control measures are undertaken (Silva et al., 2006; Van der Vossen, 2001).

Table 12. Incidence and severity of diseases observed on coffee in the major Robusta coffee growing regions of Uganda

Region	Brown Eye Spot		Coffee Leaf Rust		Red Blister Disease	
	Incidence (%)	Severity	Incidence (%)	Severity	Incidence (%)	Severity
Busoga	7.7	1.1	4.2	1.0	13.1	1.1
Rwenzori	23.0	1.2	20.0	1.2	8.9	1.1
Southwestern	77.0	1.6	61.3	1.8	25.5	1.2
Western	6.9	1.1	2.9	1.0	9.7	1.2
National mean	30.1	1.2	23.3	1.3	14.4	1.2

4. Conclusions

Coffee is an important cash crop at farm level for many households and will continue being so. However, its production and productivity is constrained by pests such as BCTB, Tailed Caterpillars, Mealybugs and diseases like; CWD, RBD and CLR which are threatening efforts geared towards increasing coffee production.

5. Recommendations

(i) Conduct massive farmer awareness campaigns on the management of BCTB. Given the scale of spread of BCTB, this will require a community approach. This will take the form of community trainings, media sensitizations on TV and radios. This is urgently needed to control the spread of the pest and limit the damage.

(ii) Given the resurgence of CWD, there is need to derive good dissemination of new technologies (CWDr varieties) and put in place a gap filling programme in each region such that trees affected by CWD are replaced with Coffee Wilt Disease Resistant varieties (CWDr).

(iii) There is need to retool and train all DLG extension workers on management of coffee pests and diseases. This will help to build their capacity to provide technical backstopping to farmers on the management of pests and diseases.

References

Adipala-Ekwamu, O. O., Kyetere, D., Hakiza, G., Tushemereirwe, W., Bua, A., Kisanzi, D., & Koyobyo, G. (2001). Background and importance of Coffee Wilt Disease in Uganda. *National Agricultural Research Organisation (NARO) Research Progress Report (1997-2000)* (pp. 1-16).

Aristizábal, L., Bustillo, A., & Arthurs, S. (2016). Integrated pest management of coffee berry borer: Strategies from Latin America that could be useful for coffee farmers in Hawaii. *Insects, 7*(1), 6. https://doi.org/10.3390/insects7010006

Arneson, P. A. (2000). Coffee rust. *The Plant Health Instructor*. https://doi.org/10.1094/PHI-I-2000-0718-02

Avelino, J., Willocquet, L., & Savary, S. (2004). Effects of crop management patterns on coffee rust epidemics. *Plant Pathology, 53*(5), 541-547. https://doi.org/10.1111/j.1365-3059.2004.01067.x

Borghi, E., Fornaciari, G., Vieira, M., Aguiar, R., Holtz, A., Filho, A., … Carvalho, J. (2021). *Planococcus* spp.: behavior and monitoring in conilon coffee crops. *Coffee Science, 16*. https://doi.org/10.25186/.v16i.1820

Damon, A. (2000). A review of the biology and control of the coffee berry borer, *Hypothenemus hampei* (Coleoptera: Scolytidae). *Bulletin of Entomological Research, 90*(6), 453-465. https://doi.org/10.1017/s0007485300000584

Dishan, M. A. (2018). Field evaluation of different coffee cultivars (*Coffea* sp.) against the infestation of coffee berry borer (*Hypothenemus hampei* Ferrari). *International Journal of Entomological Research, 6*(2), 63-73. https://doi.org/10.33687/entomol.006.02.2439

Egonyu, J. P., Baguma, J., Ogari, I., Ahumuza, G., Kyamanywa, S., Kucel, P., … Wagoire, W. W. (2009). The formicid ant, Plagiolepis Sp., as a predator of the coffee twig borer, *Xylosandrus compactus*. *Biological Control, 91*, 42-46. https://doi.org/10.1016/j.biocontrol.2015.07.011

Fletcher, A. (2008). Fungal families of the world. By P. F. Cannon and P. M. Kirk. 2007. Wallingford, Oxfordshire, UK: CAB international. Pp xiii, 456, numerous colour plates and figures, 215×300 Mm (A4). ISBN 978 0 85199 827 5, hardback. Available from CABI, Nosworthy way, Wallingford, Oxfordshire OX10 8DE, email: cabi@cabi.org, website: www.cabi.org. Price £75. *The Lichenologist, 40*(05), 463. https://doi.org/10.1017/s0024282908009158

Gaitán, A. L., Cristancho, M. A., Caicedo, B. L. C., Rivillas, C. A., & Gómez, G. C. (2015). Part II: Pests. *Compendium of Coffee Diseases and Pests* (pp. 45-60). St. Paul, MN, USA: APS Press, The American Phytopathological Society. https://doi.org/10.1094/9780890544723.003

Gutierrez, A. P., Villacorta, A., Cure, J. R., & Ellis, C. K. (1998). undefined. *Anais da Sociedade Entomológica do Brasil, 27*(3), 357-385. https://doi.org/10.1590/s0301-80591998000300005

Hakiza, G. J., Kyetere, D. T., Musoli, P., Wetala, P., Njuki, J., Kucel, P., ... Ogwang, J. (2010). Coffee wilt disease in Uganda. *Coffee Wilt Disease*, 28-49. https://doi.org/10.1079/9781845936419.0028

Jaramillo, J., Borgemeister, C., & Baker, P. (2006). undefined. *Bulletin of Entomological Research, 96*(3), 223-233. https://doi.org/10.1079/ber2006434

Jaramillo, J., Torto, B., Mwenda, D., Troeger, A., Borgemeister, C., Poehling, H., & Francke, W. (2013). undefined. *PLoS ONE, 8*(9), e74277. https://doi.org/10.1371/journal.pone.0074277

Judith, K., Godfrey, H., Abisagi, K., Patrick, K., Lilian, N., Ivette, P., & W. William, W. (2018). Farmers' knowledge of pests and diseases in the coffee-banana agroforestry systems of mid-eastern Uganda. *Journal of Agriculture and Environmental Sciences, 7*(2). https://doi.org/10.15640/jaes.v7n2a12

Kagezi, G. H., Kucel, P., Egonyu, P. J., Nakibuule, L., Kobusinge, J., Ahumuza, G., … Chesang, B. F. (2013). Impact and farmers' coping mechanisms of the Black Coffee twig borer, *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in Uganda. *African Crop Science Conference Proceedings, 11*, 285-292.

Kagezi, G. H., Kucel, P., Nakibuule, L., Kobusige, J., Ahumuza, G., Kyamanywa, S., & Wagoire, W. W. (2016c). *Modified package for managing the Black Coffee Twig Borer (BCTB)*. Technical Advice.

Kagezi, G. H., Kucel, P., Nakibuule, L., Kobusinge, J., Ahumuza, G., & Wagoire, W. W. (2016a). *Current research status and strategic challenges on the black coffee twig borer, Xylosandrus compactus in Uganda.* 2nd Scientific Conference on African Coffee. The Inter African Coffee Organisation (IACO) 56th Annual General Assembly, November 28-December 3, 2016, Yaounde, Cameroon.

Kagezi, G. H., Kucel, P., Olango, N., Tumuhaise, V., Nakibuule L., Kobusinge, J., … Wagoire, W. W. (2016d). *Current distribution and impact of the Black Coffee Twig Borer (BCTB) and Coffee Wilt Disease (CWD) in Uganda*. Study report submitted to the Uganda Coffee Development Authority (UCDA).

Kagezi, G. H., Kucel, P., Olango, N., Tumuhaise, V., Nakibuule, L., Kobusinge, J., ... Wagoire, W. W. (2016b). *Dynamics of black coffee twig borer damage on Robusta coffee in Uganda* (p. 92). NARO-MAK Joint Agricultural Dissemination Conference.

Kagezi, G. H., Kyalo, G., Helerimana, C., Twesigye, T., Musasizi, J. K., Anyijuka, M., & Ssenoga, G. (2021). *A Rapid Assessment of the Coffee Berry Moth, Prophantis smaragdina (Butler) (Lepidoptera: Pyralidae) on Robusta Coffee at Kaweri Coffee Plantation Ltd and Surrounding Villages in Mubende District, Uganda*. Technical report.

Kidanu, S., & Tesfaye, S. (2020). Occurrence and Infestation of Coffee Leaf Skeletonizer, *Leucoplema Dohertyi* (Warren) on Young Coffee Seedlings at Jimma Ethiopia. *International Journal of Research Studies in Agricultural Sciences, 6*(7), 19-23. https://doi.org/10.20431/2454-6224.0607003

Matovu, R. J., Kangire, A., Phiri, N. A., Hakiza, G. J., Kagezi, G. H., & Musoli, P. C. (2013). Ecological factors influencing incidence and severity of Coffee Leaf Rust and Coffee Berry Disease in major Arabica coffee growing districts of Uganda. *Uganda Journal of Agricultural Sciences, 14*(1), 87-100.

Mendesil, E., & Tesfaye, A. (2009). The influence of weather on the seasonal incidence of coffee berry moth, Prophantis smaragdina (Butler). *Journal of Asia-Pacific Entomology, 12*(3), 203-205. https://doi.org/10.1016/j.aspen.2009.02.005

Mendesil, E., Jembere, B., & Seyoum, E. (2004). Population dynamics and distribution of coffee berry borer, *Hypothenemus hampei* (Ferrari) (Coleoptera: Scolytidae) southwestern Ethiopia. *SINET: Ethiopian Journal of Sciences, 27*, 127-134. https://doi.org/10.4314/sinet.v27i2.18240

Mugo, H. M., & Kimemia, J. K. (2009). *The coffee berry borer, Hypothenemus hampei Ferrari (Coleoptera: Scolytidae) in Eastern Africa region: The extent of spread, damage and management systems*. ICO Seminar on the Coffee Berry Borer. Retrieved from http://www.ico.org

Mugo, H. M., Irungu, L. W., & Ndegwa, P. N. (2011). The insect pests of coffee and their distribution in Kenya, *International Journal of Science and Nature, 2*(3), 564-569.

Musoli, P. C., Hakiza, G. J., Birinkunzira, J. B., Kibirige, S., & Kucel, P. (2001). Coffee (*Coffea* spp.). In J. K. Mukiibi (Ed.), *Agriculture in Uganda* (Vol. II, pp. 376-436). Fountain Publishers/CTA/NARO.

NaCORI/NARO. (2020). *Coffee Pest and Disease Status in Central Uganda*. National Coffee Research Institute (NaCORI), National Agricultural Research Organisation (NARO) Report.

Ngoan, N. D., Wilkinson, R. C., Short, D. E., Moses, C. S., & Mangold, J. R. (1976). Biology of an introduced ambrosia beetle, Xylosandrus compactus, 1 in Florida 2. *Annals of the Entomological Society of America, 69*(5), 872-876. https://doi.org/10.1093/aesa/69.5.872

Otieno, H. M., Alwenge, B. A., & Okumu, O. O. (2019). Coffee production challenges and opportunities in Tanzania: The case study of coffee farmers in Iwindi, Msia and Lwati villages in Mbeya region. *Asian Journal of Agricultural and Horticultural Research,* 1-14. https://doi.org/10.9734/ajahr/2019/v3i229993

Ramos, J. B., Resende, M. L., Botelho, D. M., Pereira, R. C., Reichel, T., Balieiro, A. A., ... Abrahão, J. C. (2022). Screening coffee genotypes for Brown eye spot resistance in Brazil. *PLoS ONE, 17*(1), e0258822. https://doi.org/10.1371/journal.pone.0258822

Rutherford, M. A., & Phiri, N. (2006). *Pests and diseases of coffee in Eastern Africa: A technical and advisory manual*. CAB International, Wallingford.

Santa-Cecília, L. V. C., & Silva, K. H. (2020). Interaction between mealybugs (Pseudococcidae) and coffee plants. *Coffee Science* (Vol. 15). https://doi.org/10.25186/.v15i.1695

Schumann, G. L., & Leonard, K. (2000). Stem rust of wheat (Black rust). *The Plant Health Instructor*. https://doi.org/10.1094/phi-i-2000-0721-01

Shankarkumar, A. C. (2021). *Assessment of the impact of Black Coffee Twig Borer, Xylosandrus compactus infestation in Ugandan small-scale coffee gardens, and the potential of its suppression through repellence in conjunction with push-pull technology* (MSc thesis. Swedish University of Agricultural Sciences, SLU).

Silva, M. C., Varzea, V., Guimaraes, L. G., Azinheira, H. G., Fernandez, D., Petitot, A. S., … Bertrand, B. (2006). Coffee resistance to the main diseases: Leaf rust and coffee berry disease. *Brazilian Journal of Plant Physiology, 18*(1), 119-147. https://doi.org/10.1590/S1677-04202006000100010

Souza, A. G. C., Maffia, L. A., Silva, F. F., Mizubuti, E. S. G., & Teixeira, H. (2015). A time series analysis of brown eye spot progress in conventional and organic coffee production systems. *Plant Pathology, 64*, 157-166. https://doi.org/10.1111/ppa.12250

Ssembatya, F. (2017). *Economic threshold and optimal control strategies for black coffee twig borer (BCTB) on Robusta coffee: The case of Uganda* (MSc thesis, Makerere University, Uganda).

Tamiru, S., Sisay, K., Balay, A., & Demelash, T. (2017). Survey on Status of Key Coffee Insect Pests in Major Coffee Growing Areas of Ethiopia. *International Journal of Research Studies in Science, Engineering and Technology, 4*(9), 17-21.

UCDA. (2008). *Annual report*. Retrieved from http://www.ugandacoffee.org

UCDA. (2023). *Annual report*. Retrieved from http://www.ugandacoffee.org

Van der Vossen, H. A. M. (2001). Coffee breeding practices. In R. J. Clarke, & O. G. Vitzthum (Eds.), *Coffee Recent Developments* (pp. 184-201). Oxford: Blackwell Science. https://doi.org/10.1002/9780470690499.ch9

Vega, F. E., Infante, F., & Johnson, A. J. (2015). The genus *Hypothenemus*, with emphasis on *H. hampei*, the coffee berry borer. In F. E. Vega, & R. W. Hofstetter (Eds.), *Bark Beetles, Biology and Ecology of Native and Invasive Species* (1st ed., Chapter 11, pp. 427-494). Elsevier: London, UK. https://doi.org/10.1016/B978-0-12-417156-5.00011-3

Vega, F., Infante, F., Castillo, A., & Jaramillo, J. (2009). The coffee berry borer *Hypothenemus hampei* (Ferrari) (Coleoptera: Curculionidae): A short review, with recent findings and future research directions. *Terr. Arthropod Rev., 2*, 129-147. https://doi.org/10.1163/187498209X12525675906031

Ventura, J. A., Costa, H., Santana, E. N., & Martins, M. V. V. (2007). Diagnostics and Management of Diseases of Conilon Coffee. In R. G. Ferrão, A. F. A. Fonseca, S. M. Bragança, M. A. G. Ferrão, & L. H. Muner (Eds.), *Conilon Coffee*. Incaper, Vitória.

Waller, J. M., Bigger, M., & Hillocks, R. J. (2007). World coffee production. *Coffee pests, diseases and their management* (pp. 17-33). CABI, Wallingford. https://doi.org/10.1079/9781845931292.0017

Wassie, A. K. (2019). Integrated Diseased Management on Coffee Wilt Disease Caused by *Fusarium Xylarioides* and its distribution in Ethiopian. *Review Agric. Res. Technol., 23*, 302-308. https://doi.org/10.19080/ARTOAJ.2019.23.556232

Wood, S. L., & Bright, D. E. Jr. (1992). A catalog of Scolytydae and Platypodidae (Coleoptera), Part 2: Taxonomic index. *Great Basin Naturalist, Memoirs, 13*, 1-1553.

Wrigley, G. (1988). Coffee. *Tropical Agriculture* (p. 639). Longman Scientific and Technical, Harlow, UK.

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Authors Contributions

Dr. Gerald Kyalo and Dr. Godfrey Kagezi were responsible for study conception, design and manuscript drafting and revising. Charlotte Aijuka, Veronica Twesigye and Dixon Nuwagaba were responsible for tool preparation, input into Kobo collect, data cleaning and analysis. Charles Peter Apunyo, Mark Anyijuka and Jannet Musasizi were responsible for data collection. Dr. Emmanuel Iyamulemye and Dr. Geofrey Arinaitwe provided funding for the study and overall supervision. All authors read and approved the final manuscript.

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Data Sharing Statement

No additional data are available.