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Assessing the Effects of Black Coffee Twig Borer on Coffee Productivity in Kamwenge District: A Case Study of Busiriba Sub-County

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Abstract

This study aimed at assessing the effect of black coffee twig borer on coffee productivity in Kamwenge district in order to get a clear view of the damage caused by the pest such that appropriate measures of controlling it can be found. The objectives of the study were: to determine farmers' knowledge on the signs and symptoms of black coffee twig borer on coffee; establish the damage caused by black coffee twig borer on coffee productivity; and establish the available measures used by farmers to control the black coffee twig borer in the district. A cross–sectional study design that employed both qualitative and quantitative data collection techniques was used to investigate the effect of black coffee twig borer on coffee productivity. The study targeted coffee farmers, agriculture extension workers and local councils within the two parishes of Kahondo and Bigodi. The study used a sample size of 137 respondents where, 130 coffee farmers were selected systematically from lists of coffee farmers, and 4 extension workers, and 3 LC chair persons were purposively selected. The findings showed that, farmers were moderately knowledgeable on the signs and symptoms of the BCTB pest as they mentioned, drying of twigs this was by 34%, 24% that the twig & leaves above entry point of pest turn yellow, and18% that a needle sized hole at the entry of the pest. However, farmers' knowledge on the death of the plant by BCTB is very low since it was mentioned by 1.5 percent. The effects of pest attack on coffee productivity among others were reduced yields supported 30.7% and reduced house hold incomes by 25.5%. Farmers have controlled the pest by spraying with systemic pesticides confessed by 29.9%, cutting and burning infected twigs by 21.2% and daily field inspection by 16.1%. The study recommended that, the ministry of agriculture should intensify farmer trainings about this pest to capacitate coffee farmers to fight off this pest before the whole industry succumbs to it. Farmers should also employ best agronomic practices in order to fight this pest.

Keywords: Black Coffee Twig Borer, Coffee Productivity, Kamwengye district

INTRODUCTION

Background to the study

The history of coffee goes at least as far back as the thirteenth century with a number of myths surrounding its first use. The original native population of coffee could have come from Ethiopia, Sudan or Kenya, and it was cultivated by Arabs from the 14th century (Elevitch et al. 2009). Hurley (2003), states that the earliest credible evidence of either coffee drinking or knowledge of the coffee tree appears in the middle

of the fifteenth century, in the Sufi monasteries of Yemen. By the 16th century, it had reached the rest of the Middle East, Persia, Turkey and northern Africa (Wintgens, 2009). Coffee then spread to Balkans, Italy and to the rest of Europe, to Indonesia and then to the Americans. By this time, pests and diseases affecting coffee were very few. However, due to the existing climatic changes and their evolutions, many pests including the black coffee twig borer has affected many regions of the coffee world (Hurley, 2003). The black twig borer is native to Asia where it is a serious pest of Robusta coffee, but has spread to coffee growing regions throughout the world where it attacks Arabica coffee as well. Females bore into branches, twigs, and suckers, leaving a pin-hole sized entry. The plant is destroyed through tunneling as well as pathogens introduced by the borer. The black twig borer thrives in humid conditions since humidity facilitates the ambrosia fungus upon which the borer feeds in its younger stages. Infestations can be controlled by pruning (specifically removing unwanted suckers) and shade reduction (*Wintgens, 2009*)

Staples and Cowie (2007) noted that the black coffee twig borer, Xylosandrus compactus, is an ambrosia beetle that was reported in Hawaii in 1960 and attacks branches of more than 200 plant species, including coffee. This beetle was found for the first-time boring coffee berries in the district of Hilo on the island of Hawaii (Cameroon 2011). Beetles reached the endo-sperm and caused damage without making galleries or ovipositing (Smith, 2003).The black coffee twig borer was not the sole cause for coffee destruction, (Smith, 2003) indicated that a related coffee pest- tropical nut borer, Hypothenemus obscurus, a pest of macadamia nuts has been in Hawaii since 1988 and was recently found for the first time attacking coffee berries hence reducing crop productivity. Its entry hole was observed close to the blossom area or the side of the berry (Cowie, 2007). Sometimes damage was caused near the endosperm but no galleries or eggs were found. The landscape of the Kona district of the island of Hawaii is characterized by a wide diversity of plant species, including both endemic and naturalized plants that offer a wider hostage of the pests (Elevitch et al. 2009). Coffee (Coffee arabica L), and other macadamia nut (Macadamia integrifolia Maiden & Betche), and avocado (PerseaAmericana Mill.) are the main agricultural crops in the world that are affected by the black coffee twig borer (Cameroon 20011), Bitten bender and Easton Smith 1999). Coffee attack by pests has resulted into poor crop yields hence affected the GDPs and NDPs (Hurley 2003).

According to UCDA report, vol.20, (2010/11), globally, the coffee producing countries were estimated at over 314,423 bags and were estimated at US $448.8 million compared to less than US $448.8 million bags in 2010/11, a 2.1% drop as it was due to the existence of coffee diseases and pests. UCDA report, vol.20, (2010/11), noted that coffee production in most developing countries reduced from 16, 467 to13, 800 million 60 kilo bags in 2011.Recent decline in coffee production is associated to the infestation by the BCTB though there are other factors in conjunction like un conducive climatic conditions-drought, other pests and diseases such as coffee berry diseases, coffee berry borer (Bambara, 2011). According to (Wintgens, 2009), coffee governments have tried to reduce the problem of black coffee twig borer through the application of pesticides, sensitization programs but these methods have not worked efficiently. In India, BCTB is reported to cause over 20% yield loss in coffee thus the potential damage and negative impact to the economy (Cameroon 2011).

In Africa, the black Coffee twig borer is a serious pest of coffee and some agriculturally important plants such as orchids and avocado (Staples GW, Cowie 2007). According to Sulaiman Mwangu (2010), the BCTB remains a threat to the coffee industry and other shade trees. Though the African governments placed a ban on the shipment of woody plants from the Asian island, the borer still managed to escape to flourish on each and every one country on the African continent (Cameroon 2011). The Black coffee twig

borer (BCTB) continue to spread to new areas in central, south, north, and western Africa. In spite of the above, the coffee subsector continues to experience a slow pace in propagation of resistant coffee lines, generation of seedlings and containment of pests and diseases. There is as limited capacity to rehabilitate aged trees and adapt climatic changes in Africa. The coffee subsector continues to prospect for establishment of a suitable plant which involves high costs of investments (Bambara, 2011).

Uganda Coffee Development Authority (UCDA) was established by an Act of Parliament 1991 and amended in 1994, Cap.325 under the laws of the Republic of Uganda. UCDA was established as a public Authority and its mandate is to promote and oversee the coffee industry by supporting research, promoting production, controlling the quality and improving the marketing of coffee in order to optimize foreign exchange earnings for the country and payments to the farmers. Before 2004, the coffee twig borer pest affecting coffee plants was not clearly known in Uganda but the pest now affects 34 out of 80 coffee growing districts in the country and it continues to spread (UCDA 2010/11).

Uganda is currently the largest producer of Robusta coffee in Africa but as the Twig Borer continues to spread combined with the unusually dry weather, exports have remained at an average of 3 million bags in the last ten years (UCDA 2010/11). Coffee provides important source of income to 1.3 million small holder farmers who traditionally intercrop it with food crops such as bananas, beans, groundnuts and shade trees. According to UCDA report (2010/11), over 5 million people depend on the coffee sector for direct and indirect employment. With the emerging spread of Coffee Twig Borer pests in coffee, if not tackled head on, coffee production shall decline thus negatively affecting farmers' incomes as well as Economy. In Uganda, BCTB was first reported in Bundibugyo district in 1993.Second record was in Rukungiri, Kanungu and Bushenyi districts in 2002 and the Third report was in Mukono district in 2007. At the moment, almost all Robusta growing districts are affected, the most severe hit being: Mukono, Kayunga, Buikwe, Mpigi, Butambala, Luwero, Nakaseke, Masaka, Lwengo, Kanungu, Kamwenge, Mityana and Mubende (Cameroon 2011).

In 2008, COREC/UCDA estimated that 3.7% of berries on the dead twigs in Mukono and Kayunga and 12.5% for Namuganga Sub County in particular, had been lost due to BCTB. If the loss in Mukono and Kayunga is extrapolated countrywide, an estimated 3.7% reduction in coffee export volume and value would have been the result. In 2008, Uganda earned US$ 257 while in 2009/10 and 2010/11 USD 267 million and USD 448 were earned from coffee export. A 3.7% loss due to CTB would result into a loss of USD 9 million in 2008/09; USD 13.25 million in 2009/10 and USD 18.1 million in 2010/11. However, this loss is now more due to the high severity of BCTB infection, now standing between 5 – 10 percent overall (UCDA report,2009/10).

Furthermore, (UCDA 2010/11) noted that in the districts of Mukono and Kayunga 40–50 percent of gardens are infected, with 5–10 percent of green matter loss. Luwero/Nakaseke 40–60 percent of gardens are infected. Mpigi/Butambala, 40–50%, Mityana/Mubende, 40–50% and Bushenyi/Ibanda 20–30% are infected. BCTB was spreading very fast and wide and the worst hit Sub-county, Namuganga, had 100% and 86.9% infested farms and trees, respectively, and 12.5% damaged twigs. Black coffee twig borer is one major coffee threat that has lowered production and productivity in the districts of Bushenyi, Kasese, Ibanda, Hoima, Kibale Kamwenge, Kyenjojo, and Kabarole, however, Attempts to mitigate its spread and severity are being done through training farmers modern agricultural practices. According to Kamwenge district coffee platform report (2012), the pest (BCTB) remains a major threat to coffee productivity in the district. It accounts to a 0.5% reduction in coffee productivity in the district (KADIFO, 2012).

Statement of the problem

Coffee is the cornerstone of Uganda's agricultural activities and an important cash crop for small scale farmers across Africa contributing much towards the development through improvement of house hold incomes. However, coffee production is severely constrained by black coffee twig borer (BCTB) pest attack. This has caused an impact on the quality of the coffee, its prices and hence lowering farmers' incomes. According to UCDA report 2010/11, in the districts of Mukono, Mpigi, Butambala, Mityana, Mubende, and Kayunga 40–50 percent of gardens are infected by BCTB, accounting to 5–10 percent green matter loss resulting into a 3.7% loss in foreign export earnings.

The pest (Black coffee twig borer) is spreading very fast and wide to almost all robusta coffee growing parts of the country including Bushenyi, Bundibugyo, Kasese, Ibanda, Hoima, Kibale Kamwenge, Kyenjojo, and Kabarole districts (UCDA report 2010/11). It is thus eminent that if urgent mitigating measures are not applied early, the crop will succumb to the pest.

The government of Uganda through the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) and National Agricultural Research Organization (NARO), other none governmental organizations / coffee platforms such as district coffee platforms (DCPs) as well as public mandates like Uganda coffee development authority have embarked on modern agronomic practices to control the pest's severity. However, there is need for massive sensitization about the effects of the pests, its symptoms and control measures.

It is not yet clear as to what could be the exact impact of black coffee twig borer attack in Kamwenge district. It is therefore, from this background that the research intended to assess the effects of black coffee twig borer attack on coffee productivity in Kamwenge district.

Purpose of the study

The purpose of the study was to assess the effect of black coffee twig borer on coffee productivity in Kamwenge district in order to get a clear view of the damage caused by the pest such that appropriate measures of controlling it can be found.

Objectives of the study.

1. To determine farmers' knowledge on the signs and symptoms of black coffee twig borer on coffee in Kamwenge district.
2. To establish the damage caused by black coffee twig borer on coffee productivity in Kamwenge district.
3. To establish the available measures of controlling black coffee twig borer in Kamwenge district.

Research questions

1. Are farmers knowledgeable on the signs and symptoms of black coffee twig borer on coffee in Kamwenge district?
2. How has black coffee twig borer affected coffee productivity in Kamwenge district?
3. What are the measures of controlling black coffee twig borer in coffee in Kamwenge district?

Scope of the study

Geographical scope

The study was conducted in Kahondo and Bigodi parishes of Busiliba Sub County in Kamwenge district situated in western Uganda. The sub county has been growing coffee for over twenty years and so, of recent it has witnessed a challenge of black coffee twig borer pest attack to coffee which had never

happened before. This study was carried out in the two parishes of Kahondo and Bigodi which were mostly affected by the pest and therefore deemed to provide necessary information to the researcher. The sub county is composed of farmers at subsistence level, and small scale business people.

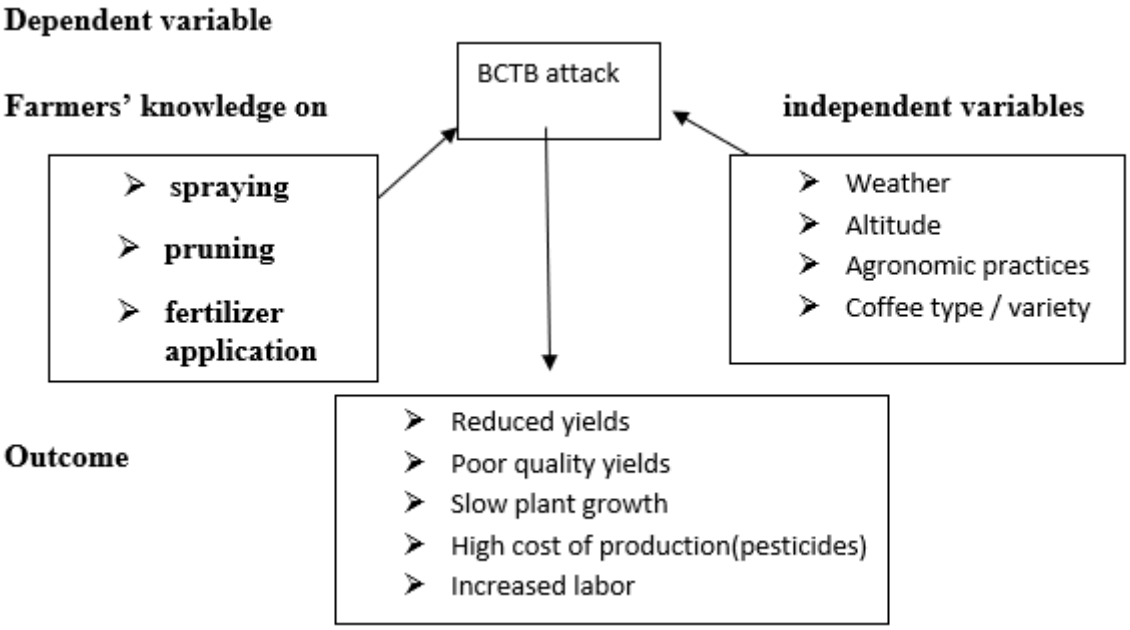
Content scope

The study assessed the effect of black coffee twig borer on coffee productivity in Kamwenge district. It aimed at achieving how the black coffee twig borer had affected coffee production, establish farmers' knowledge on the signs and symptoms of black coffee twig borer attack on coffee and find out the available measures of controlling black coffee twig borer in coffee in the district.

Time scope

The study was done in a period of 1 year and that was, 20013-2014. This enabled the researcher to capture current facts about the study.

Conceptual framework



Description

Black coffee borer attack is aggravated by weather conditions, altitude, agronomic practices, as well as coffee variety. This results into coffee reduced yields, stunted growth, poor yields, and high costs of production in terms of labor and pesticides.

Significance for the study

The study will be very useful in understanding the effects of black coffee twig borer on coffee productivity in Kamwenge district and this may be helpful as follows:

The study will expose the effects of black coffee twig borer to coffee farmers and this will assist coffee farmers to provide the appropriate measures of improving coffee in the district.

The government will find a means of how to help the farmers on how to use the advanced methods in order to reduce the problem of black coffee twig borer.

The study will further help the researcher to attain his degree since it is a requirement at the university.

LITERATURE REVIEW

Knowledge on the signs and symptoms of black coffee twig borer on coffee

According to Bambara (2007) Very small black spots/holes (about the size of a needle) or bicycle spoke appear at the point where the pest bores to enter the twig/plant. The leaves of the infected twigs start turning yellow followed by wilting and eventually die without yielding coffee berries. When the affected part is broken at the pin-hole point and split apart, small back beetles and white larvae can be seen inside the tunnel (UCDA report 2011/12). If no control measure is undertaken, death may occur to the entire coffee tree, resulting in total loss of berries and hence income (Burbano 2010).

Typical symptoms of black twig borer are wilting and death of leaves and wood beyond the beetle's entry hole (UCDA report 2011/12). The wilted leaves frequently stay on the tree but turn dry, and the bark beyond the affected area turns black (Smith, 2003). The circular entry hole, less than 1/16 inch in diameter, is usually between the last healthy leaf and the first wilted leaf on the dying lateral (Jones et al. 1992). Although a single beetle hole may kill a twig, often several burrows are required before the lateral is killed (Namwagala 2008).

Pregnant females bore into the twig to make tunnels for eggs and to grow food for the larvae (UCDA report 2011/12). The female carries a fungus, Fusarium *solani*, which she cultivates within the tunnel to feed her larvae, this fungus produces a toxin that kills the twig and leaves beyond the entrance hole (Burbano 2010). This beetle (black coffee twig borer) generally attacks trees weakened by drought, girdling, heavy pruning, standing water, or lack of fertilizer. However, some coffee cultivars are more susceptible than others (UCDA report 2011/12).

How black coffee twig borer has affected coffee productivity

According to Cameroon (2011), the black coffee twig borer has invaded coffee plantations in many regions leaving several farmers counting heavy losses. The borer attacks the twigs rendering the plant incapable of bearing coffee beans. When a twig borer attacks a coffee plant, it creates holes in it and causes a white fungus to grow around it. Mwangu (2010) stated that a coffee farmer in Uganda has lost about one acre of his plantation to the pest. He appeals for the urgent intervention of the district production department to control the pest. Furthermore, Kuliva (2008), noted that a farmer in all villages of the world loose three acres of his colonel coffee plantation to the pest. Though farmers have tried to cut down infected plants but the pest has persisted for the last 10 years.

Black coffee twig borer attacks Arabica coffee as well. Females bore into branches, twigs, and suckers, leaving a pin-hole sized entry (Namwagala, 2008). The plant is destroyed through tunneling which blocks the transporting vessels that hitch photosynthesis and translocation resulting into dying of twigs and hence wilting of the affected plant (Cameroon, 2011). The black Coffee twig borer thrives in humid conditions since humidity facilitates the ambrosia fungus upon which the borer feeds in its younger stages. Infestations can be controlled by pruning (specifically removing unwanted suckers) and shade reduction (Wintgens, 2009).

Measures of controlling black coffee twig borer on coffee production

There are a few different ways to control the pest – some to prevent attack, and others to deal with damaged fruit. Pesticides are only useful before the seed has been infested. A few different pesticides can be used however; there has been a ban in some countries for the unsustainable and negative impact on the environment (Namwagala 2008).

To diminish the black twig borer problem, coffee farmers must always take care to remove and destroy as much beetle-infested plant material as possible (Hara and Tenbrink 1994). Step number one to controlling

the black twig borer is to monitor the plants at risk Hara and (Namwagala 2008). Susceptible plants should be checked for premature yellowing of the leaves which are the most prominent sign of an infestation (UCDA report 2011/12). Once located, the branch should be inspected for pinholes 1/32 inch in diameter, if none are visible; experts suggest that you try gently bending the branch to test for weakness (Wintgens, 2009). The petiole will break at the point of entry if it is infestation and occasionally you may even see a tiny beetle scurry out (Hara and Sewake 2009). Most farmers eliminate the infested material by burying, burning, or simply removing it from the vicinity. If the infested material is not eliminated then it will remain active and could potentially serve as a breeding ground for even more of the borers (UCDA report, 2009/10).

In an UH CTAHR experiment, researchers removed all of the infected branches from the coffee trees growing on a given plot of land in Kona, they then applied fertilizer once a week through the irrigation system (Burbano 2010). The researchers were unable to find any more borer damage after a 4 months period of continuing this procedure. Next, they stopped applying fertilizer for just a month and the borers quickly returned (Burbano 2010). Based on this experiment and the advice of many experts, the most effective method of control for these insects is to maintain healthy plants. Unfortunately, this is not an easy endeavor for farmers in developing worlds. Water is a very expensive commodity for developing worlds, and fertilizing coffee plants to the extent required is just not very feasible. Mature trees require a minimum of at least 1,600 pounds of fertilizer for each acre of land every single year (Wintgens, 2009). There are a variety of pesticides and several biological control methods which are semi-recommended by professionals, but it is debatable as to whether or not they are effective.

The best control is maintaining healthy trees. Infested laterals should be pruned behind the last entrance hole as soon as wilting is observed, because new adults will emerge in a few weeks. Pruned laterals should immediately (the same day, if possible) be chipped, burned, or buried to kill the beetles and young (Wintgens, 2009). Simply cutting off the wilted lateral and leaving it in the orchard will not kill the adult or young-they will leave the lateral and move to another tree. No insecticide registered for coffee is effective against this pest (Jones and Johnson 1996).

One pesticide suggested is chlorpyrifos, one of the most-widely used active ingredients for pest control products in the world (Dow Agro Sciences 1998). According to (AgroSciences 1998), Chlorpyrifos is 100 percent effective on adult females of X. compactus Unfortunately, information regarding this statement is unavailable and so we cannot ascertain as to whether or not their method of application is feasible either. However, we do know that chlorpyrifos is one of the most effective pesticides used to eliminate over 250 species of insects. It is an organophosphate insecticide which means that like other organophosphates it is an acetylcholinesterase inhibitor resulting in excessive transmission of nerve impulses and eventual death of the insect (Dow AgroSciences 1998).

X. compactus has also been controlled in India through use of an insecticide called monocrotophos (Davis and Dute 1997). Aside from being banned from use in the United States in 1989, monocrotophos is another organophosphate but it is much more highly toxic than chlorpyrifos (Oliver and Mannion 2001). It is extremely poisonous to birds, mammals, and is used specially to control a variety of sucking, chewing, and boring insects and spider mites (Pesticide News 1997). In fact, the Environmental Protection Agency (EPA) classifies monocrotophos as having a class I(one) toxicity, meaning it is highly toxic (Pesticide information profiles 1995). It is remarkably lethal when ingested orally, as well by inhalation or absorption through the skin. Just to name a few, symptoms of poisoning may include excessive sweating, headache, weakness, giddiness, nausea, vomiting, hyper salivation, abdominal cramps, diarrhea, blurred vision, and

slurred speech (Pesticide News 1997). Luckily for the twig borer, Hawaiians will not be using this pesticide any time soon, although it does sound like monocrotophos could be a very effective weapon.
In reality, black twig borers are just extremely difficult insects to control. The fact that they hide within the host tree and rarely emerge except to find a new host creates a sort of barrier between beetle and chemical. Therefore, insecticides would need to be applied to the tree prior to the borer's arrival and have long residual activity in order for any dent to be made whatsoever (Oliver and Mannion 2001). According to Uganda coffee development Authority Coffee extension bulletin No.11, application of systemic pesticides like IMAX, Confidor, can be effective on BCTB.
There are a few potential biological twig borer controllers. The black twig borer is parasitized by eulophid wasp of the genus Tetrastichus (Fricola 2008). Nine species of Tetrastichus were introduced to Hawaii (either accidentally or on purpose) to parasite the twig borers. In the 1960s, three different species of braconid wasps were officially introduced by the Hawaii Department of Agriculture, though none of them became permanently established (Hara and Tenbrink 1994), so far, there could be no other more natural methods of control known to act effectively against X.compactus. To my opinion, further studies should be conducted in the area of biological control, especially involving the parasitizing wasps.

RESEARCH METHODOLOGY

Area of study

The study was carried out in Busiriba Sub County- Kamwenge district in western Uganda just lying between Ibanda and Kabarole districts. The district is composed of 13 sub counties and one town council making a total of 14 lower local governments. The district just like any other, is made up of both political and administrative units who perform different administrative roles-the political unit is all policy making as the technical unit for technical administration (technical guidance and implementation).
The economy of the area is predominantly dependent on agriculture, and a small percentage of small-scale business. Agriculture in the area is dominated by subsistence farmers who deal in traditional food crops such as banana, cassava, maize and beans, small scale livestock farming and poultry.
The population largely depend on coffee (Robusta) production for cash. Coffee farming in this area has been fostered by the low altitude and a well distributed rainfall received, coupled with the production department that has offered advisory service on coffee production. This area has been growing coffee for over twenty years albeit, different challenges of pests and diseases such as mealy bugs, coffee berry disease, coffee wilt, and fluctuations of coffee prices, to mention but a few, have been in a play. Currently the black coffee twig borer pest has infested the district with the two parishes of Kahondo and Bigodi of Busiriba Sub County mostly affected. The sub county besides, coffee producers, is composed of arable farmers at subsistence level, and small scale business people
According to Kamwenge district coffee platform report (2012), the pest (BCTB) remains a major threat to coffee productivity in the district. It accounts to a 0.5% reduction in coffee productivity in the district (KADIFO, 2012). The study therefore was conducted in the two parishes of Kahondo and Bigodi - Both parishes have been growing coffee for the past twenty years and are highly infested by the pest.

Research design

The researcher used a cross–sectional study design that employed both qualitative and quantitative data collection techniques to investigate the effect of black coffee twig borer on coffee productivity in Kamwenge district. The design helped to determine farmers' knowledge on the signs and symptoms of

black coffee twig borer on coffee and to establish the available measures of controlling black coffee twig borer by farmers in Kamwenge district.

Study population

The study targeted coffee farmers, agriculture extension workers, and local councils. Both males and females were engaged in the study. This helped the researcher to get different information from different groups of the people thus believe that the respondents were able to provide the necessary information for the study.

Population sample

The researcher used statistical formula $n = z^2pq / d^2$ or $n = z^2p(1-p) / d^2$ (Gogate N. 2010) to determine sample population.

Description

n = required sample size

z = confidence level at 95% (standard value 1.96)

p = estimated percentage of damage caused by pest

d = margin of error at 5% (standard value)

Where z = 1.95

p = 10%

q = (1-p) = 1 - 0.1 = 0.9

d = 5% = 0.05

$n = 1.95^2 \times 0.1 \times 0.9 / 0.05 \times 0.05$

n = 137

The study therefore used a sample size of 137 respondents. These respondents consisted of 130 coffee farmers -65 from each parish, 4 extension workers, and 3 LC chair persons (LCIII, and the two LCIIs of the respective parishes).These respondents were selected because they were believed to have a lot of knowledge on coffee production and productivity and therefore expected to give the needed information about the study.

Sampling procedure

This study was conducted in Kamwenge district, Busiriba sub-county. This district was purposively sampled because the researcher works in there and that it is one of the severely CBTB infested areas in Uganda. Busiriba Sub County was also purposively sampled because it is the most affected sub county with the pest. The two parishes of Kahondo and Bigodi were randomly selected from the five parishes of the sub county in the district by using numbered papers which were shaken in a basin and then two numbered papers were randomly picked from the basin. These papers were for the two parishes of Kahondo and Bigodi.

Selection of respondents

Selection of respondents from the sub county was done using systematic and purposive sampling techniques.

Coffee farmers were selected systematically from lists of coffee farmers. A list of coffee farmers in the two parishes was collected from the sub county from which 65 farmers were systematically selected from each parish.

The 4 extension workers were selectively purposively because they were the only ones in the sub county (area of study) deemed to have the necessary technical knowledge about coffee as well as the black coffee twig borer pest. These extension workers included-the sub county NAADs coordinator, the agricultural

advisory service provider – crop based / traditional Agricultural extension worker, and the two (2) community-based facilitators.

The local council chair persons were sampled purposively because they were the only ones in the area of study and therefore well vast with any incidence taking place in the area, they are also residents of the area, above all they are the policy makers and therefore conversant with any bye-laws against BCTB control in the area. These included the chairperson LC111 and the two LC11 chairpersons one from each parish.

Research instruments and tools

Interview guide

This technique was used to get the raw data from extension workers and local council leaders. Questions were asked to the informants orally as they give their preferred answers mean while the researcher jotted down the answers. Interview guides also helped to get data from respondents who could not be able to read. Interview guides helped to solve the problem of language barrier (English problem) to some respondents during data collection.

Observation method

This involved the collection of information using the senses such as hearing, seeing and listening. Direct observation was used to acquire non verbal information that was important in justifying the validity of the data provided. This method helped to collect first-hand information from the field in a non-verbal behavior.

Observation checklist was used by the researcher by looking at the available practices employed to control the pest, observe affected plants by black coffee twig borer and the symptoms exhibited. This assisted in checking the effects of black coffee twig borer on coffee productivity in the mentioned study area. Therefore, it helped the researcher to have a clear understanding of his study as he discussed with the respondents.

Questionnaires

Researcher structured questionnaires were used to collect data from farmers. The researcher set structured questions on paper and administer them to the selected respondents. The respondents filled the questionnaires appropriately and returned them to the researcher who later analyzed them for presentation. Key informant interviews were used to collect data from extension workers, the researcher interviewed the extension workers as he recorded their responses.

Data quality control

Content validity was assured by pre-testing the questionnaire, training some of the people to administer the questionnaire, and by cross checking the questionnaire each day after data collection from the field.

Study variables

The study encompassed both independent and dependent variables.

a, the dependent variable was the black coffee twig borer attack.

b, independent variables were;

- Weather
- Altitude
- Agronomic practices
- Coffee type / variety

Data analysis

Data analysis encompassed both qualitative and quantitative data. Data was analyzed using computer

packages of Microsoft excel and SPSS. Data was fed into computer excel and SPSS for analysis and presented in tables, pie charts and graphs. Thematic analysis helped in creating a systematic flow of the study findings by pointing out the major sections based on study objectives and sub sections based on questions developed under each objective. Discussions, recommendations and conclusions were made in relation to the study objectives.

Ethical consideration

Institutional consent

The researcher first acquired an introductory letter from the Faculty of agriculture introducing him as a student, which he presented to the relevant authorities seeking for permission to conduct his research in the area of interest-district, Sub County, and parishes.

Informed consent

The researcher made appropriate approaches so as to obtain information from the respondents. The researcher first introduced himself to respondents, and then explained clearly the objective of the study to the respondents such that they acquire a clear over view of the study. Respondents were assured that the information provided would be treated highly confidential and that their names and personal details would not be revealed. This was enough to convince the respondents to give appropriate information to the study.

Content validity

Content validity was assured by consulting my research supervisor for appropriate guidance. The questionnaire was first pretested before being administered to the respondents for data collection.

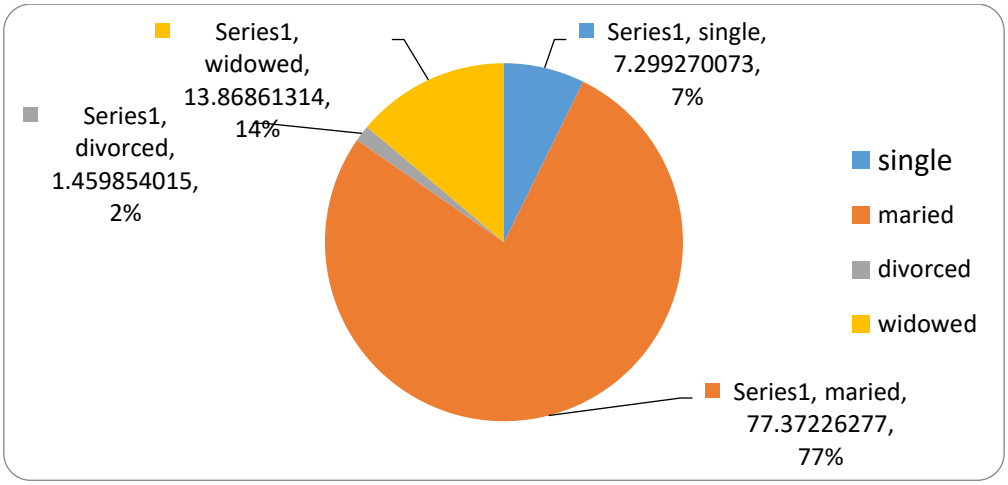
DATA ANALYSIS PRESENTATION AND INTERPRETATION

Table 1: Sex of the respondents n = 137

Sex		Frequency	Percent
	Male	54	39.4
	Female	83	60.6
	Total	137	100.0

Majority of respondents interviewed 83 (60.6%) were females, and 54 (39.4%) of the total respondents were males.

Figure 1: Marital status of respondents n = 137



Slightly more than three quarters of respondents 106 (77%) were married followed by 19(14%) widowed and 10(7%) single.

Table 2: Respondents by age n = 137

Age	Frequency	Percent
below 18 years	6	4.4
18-30 years	27	19.7
31-43 years	71	51.8
44 yrs & above	33	24.1
Total	137	100.0

Half of the respondents 71(51%) were in the age bracket of 31-43 followed by 33(24.1%) in the age range of 44 and above, and 27(19.7%) aged between (18-30year). The lowest number of participants 6 (4.5%) was below 18 years of age.

Figure 2: level of education of respondents

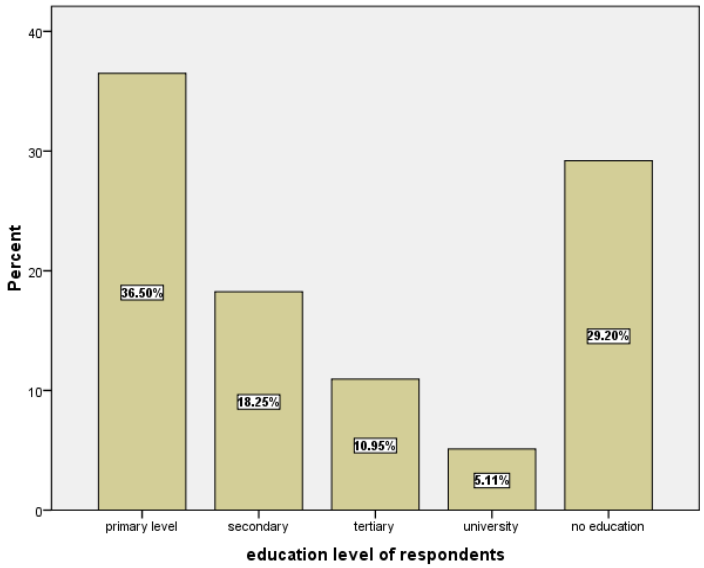


Figure 2 above shows that 50(36.5%) of the respondents had attained primary level of education while 40 (29.2%) had no level of education. Those with secondary and tertiary level of education were 25 (18.2%) and 15 (11.0% respectively).

Table 3: Occupation of respondents n = 137

	occupation	Frequency	Percent
	Farmer	130	94.9
	local leader	3	2.2
	extension staff	4	2.9
	Total	137	100.0

From the table above, majority of the respondents-130(95%) were farmers, 4 respondents (2.9%) were extension staff while 3 (2.2%) were local leaders.

Farmers' knowledge on the signs and symptoms of the black coffee twig borer in coffee

Table 4: Signs and symptoms of black coffee twig borer attack on coffee

Signs and symptoms of BCTB attack on coffee.	Frequency	Percent
twig & leaves above entry point of pest turn yellow and wilt	33	24.1
drying of infected twigs	47	34.3
needle sized hole at the entry of the pest	25	18.2
yellowish powder at the pin hole	10	7.3
tunnel with eggs, white larvae, and black beetles inside the infested twig	20	14.6
death of whole plant in severe conditions	2	1.5
Total	137	100.0

The most frequently mentioned sign and symptom was drying of twigs this was mentioned by 47 respondents (34%), 33 respondents (24%) revealed that the twig & leaves above entry point of pest turn yellow, and 25(18%) mentioned a needle sized hole at the entry of the pest. The other mentioned symptoms can be seen the table above.

Table 5: conditions for severity of pest infestation

conditions for severity of pest infestation	Frequency	Percent
weed infested(bushy) plantations	40	29.2
dry weather conditions	25	18.2
neglected plantations	45	32.8
Robusta coffee(type)	7	5.1
poor soil nutrients	10	7.3
I don't know	10	7.3
Total	137	100.0

Almost a third of respondents 45(32.8%) pointed out that black coffee twig borer pest is severe in neglected plantations, 40 (29.2 %), in bushy plantations, 7.3(10%) in poor soil nutrients, and a smaller proportion of respondents7 (5.1%) mentioned Robusta coffee variety.

Effects of black coffee twig borer on coffee productivity

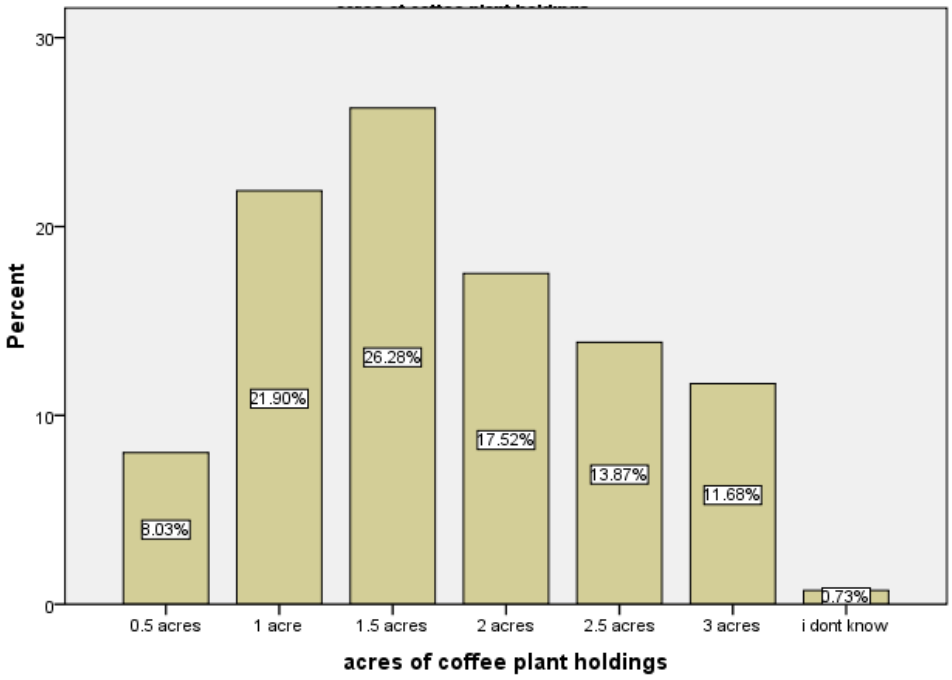


Figure 3: acres of coffee plant holdings n = 137

Slightly more than a quarter 36 (26.28%) of respondents had 1.5 acres of coffee plants, 30(21, 9%) had 1 acre, 24(17.5%) of the total population were practicing coffee farming on 02, acres.1 (0.7%) of the respondents did not know how much coffee land they owned.

Type of coffee of coffee grown

From the study findings, majority of respondents 133 (97%) grow Robusta coffee only and 4 (03%) percent grow both Arabica and Robusta.

Table 6; Time reported year of pest attack

Reported time of pest attack on plantation	Frequency	Percent
In year 2012	34	24.8
In year 2013	63	46.0
I don't know	40	29.2
Total	137	100.0

Slightly less than a half of the respondents 63(46%) mentioned year 2013 as time when their coffee plantations were attacked by the pest while 34 (25%) mentioned year 2012. A significant number 40(29.2) could not tell the exact time when their plantations were attached by the pests.

Table 7: Amount of coffee (Kiboko) in bags harvested before pest infestation

Bags of Kiboko coffee harvested before the pest attack.	Frequency	Percent
1-6	36	26.3
7-12	53	38.7
13- 18	48	35.0
Total	137	100.0

Majority of the respondents 53(38.7%) harvested 7-12 bags of Kiboko before the pest attack,48 (35.0%) and a small proportion of respondents 36(26.3%) before the pest had attacked their plantations.

Table 8: Amount of coffee (Kiboko) in bags harvested after the pest infestation

	Bags of Kiboko harvested since pest attack	**Frequency**	**Percent**
	1-6	51	37.2
	7-12	69	50.4
	13-17	17	12.4
	Total	137	100.0

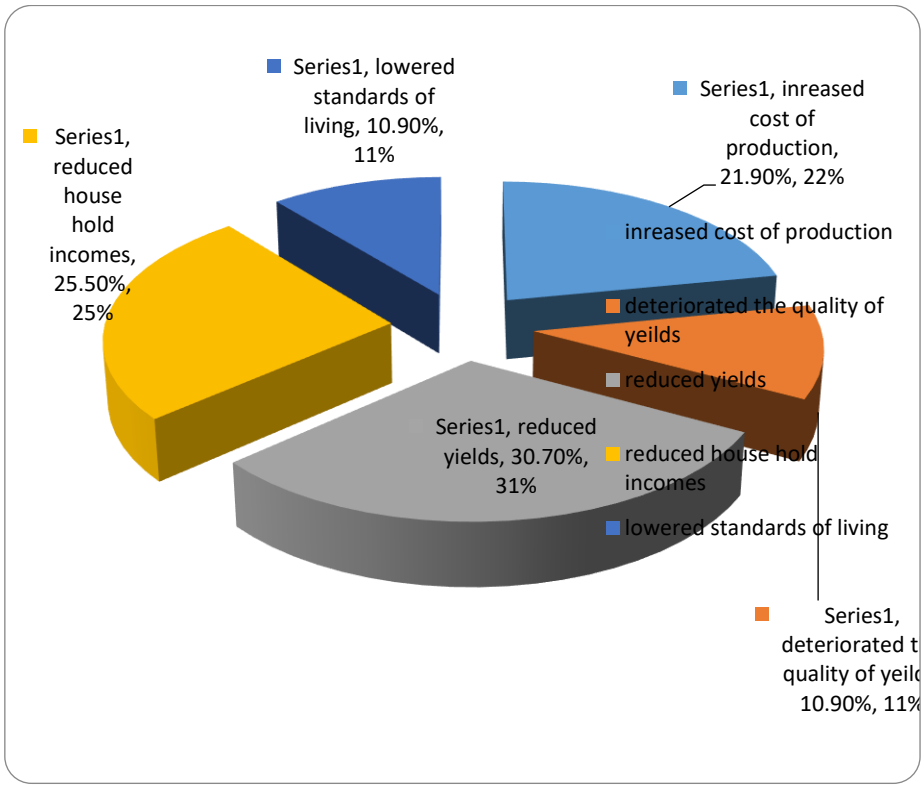
Since the infestation by the pest more than a half 69 (50.4%) of the respondents were harvesting 7-12 bags of Kiboko, 51 (37.2%), and 17 (12.4%) were harvesting 1-6 and 13- 17 bags of Kiboko respectively.

Table 9: Summarized statistics of harvests before and after pest attack

Coffee harvest	Minimum	Maximum	Mean
Bags of kiboko harvested Before pest attack	1	6	3.57
Bags of kiboko being harvested since the pest attack	1	5	2.99

Before the pest, minimum harvest was one bag of kiboko maximum harvest was 6 bags averaging to 3.57 bags. Since pest attack, maximum bags harvested were 5 averaging to 2.99 bags by each farmer per season.

Figure 4: Reported effects of pest attack on coffee productivity



The most frequently reported effect of pest attack on coffee productivity was reduced yields –42(30.7%) followed by reduced house hold incomes 35(25.5%). The least reported was deteriorating the quality, and reduced standards of life by 15(10.9%) each.

Known and reported measures of controlling black coffee twig borer

Table 8: shows the available measures used to control the pest

Reported measures of controlling the pest	Frequency	Percent
Daily field inspection	22	16.1
Cutting and burning infected twigs	29	21.2
Pruning and de-sucking	20	14.6
Fertilizer application to ensure soil nutrients	5	3.6
Spraying with systemic pesticides	41	29.9
Clean weeding	20	14.6
Total	137	100.0

The most reported measure of controlling the pest 41(29.9%) was by spraying with systemic pesticides, followed by cutting and burning infected twigs 29(21.2%), and daily field inspection with 22(16.1%) respondents. fertilizer application was least mentioned with 5(3.6%) of the total respondents.

Farmers' recommendations

Farmers recommended that government should arrange for blanket spraying regimes. Intensification of extension trainings, introduction of pest resistant coffee varieties, and byelaws that reprimands those neglecting their plantations can help to fight the pest.

DISCUSSION OF RESULTS

Demographic characteristics of the respondents.

Sex of respondents

In this study majority 61% of respondents were females and the rest were males. This implies that by most women were present at home at the time of conducting the study; men could have gone out to for other work.

Marital status of respondents

From the study, 77.4 % of the respondents were married followed by the Widowed (13.9%), the single and then the divorced (1.5%) with the least percentage. Married people have a lot of domestic challenges which need a lot of financial attention that makes them the most active players in coffee production to raise their financial standards to capacitate them sustain their families' needs. On the contrary the widowed have less land for active coffee production. Family members of the deceased in most African cases normally deprive widows of the land. The single who are largely the youth, coupled to their less family burdens that financially pressurize them, normally want to go out in towns for white color jobs that make them less active in rural coffee production, they in addition want very fast (spot) paying jobs and therefore take coffee to be very less lucrative since it takes years to yield. Lastly the divorced, are least active participants in coffee production because most of them lack land to plant this perennial crop, secondly they seem a bit relieved from family financial demands.

Age of respondents

Most of the respondents were aged 31-43 and above 44. These were middle aged and elderly. The minority was the youths and those aged less than 18.the elderly and middle aged were most by the time of conducting the research. At this age, some have retired from service as well as town life and the only way to go is through active coffee production for a better living. The young were few, they are mostly school going and therefore could have been at school by the time of this study. None school going ones, prefer looking for a living in urban centers. They on top look at coffee farming as an old man's business (they think it is for the aged). Albeit, some young, who would wish to engage actively in coffee farming, get hovered by land scarcity. Most of them do not own land over which to practice this perennial business. Since coffee production is highly practiced by the aged, who do not have enough energy to employ better agronomic practices in coffee result into poor management and hence aggravated pest problems.

*Farmers' knowledge on the signs and symptoms of black coffee twig borer on coffee***.**

Slightly more than third of respondents (34.3%) revealed that the twigs affected by the black coffee twig borer dry. This indicates that farmers have knowledge about this symptom. The twigs are seen black and dry while still on the major plant. This is in line with *Burbano* (2010) who elaborates that the female pest carries a fungus, Fusarium *solani*, which she cultivates within the tunnel (twig) to feed her larvae, this fungus produces a toxin that kills the twig and leaves beyond the entrance hole. All the constituents of the twig such as leaves, and berries do not fall off they get dry but still attached. "In fact all the coffee berries dry on the twig", a local council chairperson elaborated.

Nearly a quarter of respondents (24.1%) had knowledge on the signs and symptoms of the BCTB, they

revealed that twigs and leaves above the entry point of the pest turn yellow and finally wilt. The wilting of the twigs and leaves above the entry point of the pest indicates none functionality of the part. This is in line with different authors: according to (UCDA report 2011/12), Typical symptoms of black twig borer are wilting and death of leaves and wood beyond the beetle's entry hole. Smith (2003) elaborates that, the female beetle inoculates ambrosia for her larvae to feed which eventually poisons the twig beyond the entry point to wilt. The wilted leaves frequently stay on the tree but turn dry, and the bark beyond the affected area turns black. The leaves of the infected twigs start turning yellow followed by wilting and eventually die without yielding coffee berries. This manifests that farmers have the knowledge on this symptom.

Respondents (18.2%) mentioned that they observe a needle sized hole at the entry of the pest. When the pest bores into the plant, a small hole through which it enters remain at the entry point. This is evident that farmers are knowledgeable about the symptoms of the pest. In an interview with the extension workers, they explained that "At the start point of the drying twig, there is seen a small hole of a pin size. This is the only way to differentiate this pest from other diseases that cause twigs to dry". This is in support with Jones et al (1992), who put that circular entry holes, less than 1/16 inch in diameter, is usually between the last healthy leaf and the first wilted leaf on the dying lateral. In relation to Bambara (2007), Very small black spots/holes (about the size of a needle) or bicycle spoke appear at the point where the pest bores to enter the twig/plant.

A small fraction (7.1%) of respondents revealed that a yellowish powder observed at entry hole signifies attack by black coffee twig borer pest. Respondents described it to look like "curry powder". This signified that farmers have knowledge on the pest. The yellowish powder is the fungus ambrosia that the larvae of the pest feed on. The pregnant females after boring and tunneling the plant, it lays its eggs into the tunnel and then plants the ambrosia on which the larvae feeds. It is this ambrosia that kills the functionality of the plant. This conquers with Namwagala (2008), who asserts that the female carries a fungus into the tunnel to feed her larvae. However, this being observed by a small percentage signifies a low level of farmers' knowledge on this symptom.

It was revealed (14.6%) that when the affected twig is broken and split, Tunnel with eggs, white larvae, and black beetles are seen. Farmers are knowledgeable about the symptoms of the pest; they can split open the twigs to confirm BCTB infestation. This is in line with Bambara (2007), who put that pregnant females bore into the twig to make tunnels where it lays its eggs. The eggs eventually hatch into larvae that graduate into adult black beetles. These larvae feed on the fungus that the mother grows into the tunnel before developing into adults. When the affected part is broken at the pin-hole point and split apart, small back beetles and white larvae can be seen inside the tunnel.

A smallest proportion of respondents (1.5%) revealed that the pest when not controlled early leads to death of the whole plant. Farmers have a slight knowledge on BCTB killing the plant. This is because the pest is still new in the area and therefore very few cases of dead plants have been noticed. The BCTB kills a twig one after the other and eventually a whole plant dies. Related to this is Namwagala (2008), the grown fungus into the twig to feed the larvae produces a toxin that kills the twig and leaves. If this is extrapolated to many laterals, it can result into death of the entire plant.

How the black coffee twig borer has affected coffee productivity

A quarter of respondents (25.5%) urged that the black coffee twig borer pest has increased the cost of producing coffee. This means that it is expensive to control the pest. Controlling this pest requires intensive labor which requires enough financial input. The pesticides used in spraying against this pest are very

expensive for ordinary farmers. One farmer explained that “costs for the pesticides have drained us”. Putting in consideration, these pesticides are not sprayed as a single dose; they are sprayed in intervals depending on the chemical. This makes the spraying exercise more hectic in terms of finance and labor. Better agronomic practices like pruning, de-sucking, and clean weeding also require an extra cost in terms of inputs purchase such as pruning saws, secateurs, to mention but a few. Fertilizer application to ensure soil nutrients as another measure of controlling the pest also increases the cost of production. This is in line with Burbano (2010), who elaborated that, In an UH CTAHR experiment, researchers removed all of the infected branches from the coffee trees growing on a given plot of land in Kona, they then applied fertilizer once a week through the irrigation system. The researchers were unable to find any more borer damage after a 4 months period of continuing this procedure.

Some respondents (10.9%) revealed that the black coffee twig borer has deteriorated the quality of coffee yields. Respondents revealed that since the pest attack, they have been harvesting shriveled beans, other respondents revealed that they now harvest light beans. Once the plant is weakened by the pest, its vigor lowers and eventually ends up forming unhealthy beans. This is in line with Sulaimani Mwanga (2010) who explains that the quality of a produce is dependent on the health of a plant, plants deficient of nutrients will be incapable of yielding satisfactorily.

A bout a third of respondents (30.7%) claimed that the black coffee twig borer pest has reduced coffee yield. Before the pest, average harvest was 3.57 bags per farmer per season. Since pest attack, it reduced averagely to 2.99 bags by each farmer per season resulting into an average loss of about 1 bag of Kiboko per farmer per season. The pest causes twigs to die without yielding berries. Berries attached on the affected twigs also die prematurely causing a reduction in yields. Leaves on the affected twigs also die reducing the photosynthetic capacity of the plant resulting into reduced yields of the plant. a farmer lamented that the pest has caused her plantation to harvest almost three quarters (75%) of what he used to harvest before (25% yield loss). this is in line with the COREC/UCDA (2008), estimate that, 3.7% of berries on the dead twigs in Mukono and Kayunga and 12.5% for Namuganga Sub County in particular, had been lost due to BCTB. If the loss in Mukono and Kayunga is extrapolated countrywide, an estimated 3.7% reduction in coffee export volume and value would have been the result. Relating to Kamwenge district coffee platform report (2012), the pest (BCTB) remains a major threat, accounting to a 0.5% reduction in coffee productivity in the district.

A quarter of respondents (25.5%) revealed that black coffee twig borer has resulted into a reduction in house hold incomes. Farmers elaborated that they have been relying on coffee for their incomes. Since the emergency of the Coffee Twig Borer pests, the level of coffee production has declined thus reducing incomes. This is in line with Bambara (20110), who put that BCTB causes an impact on the quality of the coffee, its prices and hence lowering farmers’ incomes. Coffee provides important source of income to 1.3 million small holder farmers who traditionally intercrop it with food crops such as bananas, beans, groundnuts and shade trees. Over 5 million people depend on the coffee sector for direct and indirect employment.

A smaller percentage of respondents (10.9%) claimed that black coffee twig borer has lowered the standards of living of the people. Black coffee twig borer infestation has lowered both the quality and quantity of yields that has resulted into low coffee prices and low incomes respectively. The incomes from coffee has been helping coffee dealers to meet their needs like school fees, health, food, water housing, to mention but a few. By lowing incomes (productivity), coffee dealers are no longer finding it smoother meeting these needs (living poorly). This does not go far from Cowie (2007), who put that, over 5 million

people depend on the coffee sector for direct and indirect employment, and with the emerging spread of Coffee Twig Borer pests, coffee production has declined thus negatively affecting farmers' incomes as well as the Economy and if not tackled head on, the whole industry will succumb to it.

Measures used by farmers to control the black coffee twig borer pest

Some respondents (16.1%) revealed that they have controlled the spread of the pest through daily field inspection to establish new infected cases. Established infected Twigs have been cut off and burnt to reduce spread of the pest. This is in line with Hara and Tenbrink (1994) who asserted that, to diminish the black coffee twig borer problem, coffee farmers must always take care to inspect, remove and destroy as much beetle-infested plant materials as early as possible.

Slightly less than a quarter of respondents (21.2%) revealed that, they have controlled the pest by cutting and burning infected twigs / branches. Farmers confessed that cutting and burning of infected twigs has tried to call down the severity of the pest. This relates with Hara and Namwagala (2008) who said, Step number one to controlling the black twig borer is to monitor the plants at risk, eliminate the infested material by burying, burning, or simply removing it from the vicinity. If the infested material is not eliminated then it will remain active and could potentially serve as a breeding ground for even more of the borers.

Some respondents (14.6%) revealed that, they have controlled the pest through pruning and de-sucking to maintain the trees at optimum shade. Pruning and de-sucking deprives the pest of the suitable conditions for its survival. This is in line with (*Wintgens, 2009*), who highlighted that; the black twig borer thrives in humid conditions since humidity facilitates the ambrosia fungus upon which the borer feeds in its younger stages. Infestations can be controlled by pruning (specifically removing unwanted suckers) and shade reduction.

The least percentage (3.6%) of revealed that they have controlled the pest by, enriching the soils with nutrients through mulching and fertilizer application. This has boosted plants' immunity to withstand the pest. This is in line with Wintgens (2009) who explained that this beetle (black coffee twig borer) generally attacks trees weakened by drought, girdling, heavy pruning, standing water, or lack of fertilizer; the most effective method of control for these insects is application of fertilizer to maintain healthy plants. Unfortunately, this is not an easy endeavor for farmers in developing worlds. Fertilizing coffee plants to the extent required is just not very feasible. Mature trees require a minimum of at least 1,600 pounds of fertilizer for each acre of land every single year to effect plant health.

Slightly more than a quarter of respondents (29.9%) confessed that they have managed the pest through spraying with systemic pesticides. Generally, since the pest can reproduce pathogenetically without mating and can fly about 200meters a day, it is highly invasive that pesticide application is a very swift method of controlling it. This is in line with Oliver and Mannion (2001) who advised that, the fact that the black twig borers hide within the host tree and rarely emerge except to find a new host creates a sort of barrier between beetle and chemical, application of systemic pesticides can be effective. As a matter of efficiency, insecticides would need to be applied to the tree prior to the borer's arrival and have long residual activity in order for any dent to be made whatsoever.

Conclusions

From this study, the following conclusions can be made on the farmers' knowledge on sign and symptoms of the black coffee twig borer, effects of the pest on coffee productivity, and the control measures employed by farmers mitigate the pest:

- Farmers have a relative knowledge on the signs and symptoms of the coffee twig borer. that, the affected twigs &leaves above entry point of the pest turn yellow and wilt, infected twigs dry off, Needle sized holes are seen at the entrance of the pest, Yellowish powder observed at the pin hole, the affected twig if broken and split, a Tunnel with eggs, white larvae, and black beetles are seen inside the infested twigs, and that the whole plant dies in severe conditions of the pest attack.
- Some farmers fail to clearly distinguish this pest from other plant abnormalities. Their knowledge to systematically analyzing signs and symptoms is still low. Farmers concentrate on only signs and symptoms with bigger significances such as drying of the twigs and ignore or lack knowledge about those with smaller magnitudes such as ambrosia on the pinhole and a needle sized hole on entrance of the beetle. This makes them to mistaken the pest for others.
- The black coffee twig borer pest has affected coffee productivity by increasing the costs of production through the purchase of pesticides, labor, and fertilizers. It has deteriorated the quality of coffee yields. And finally, reduced coffee yields through drying of the twigs and contents. This has resulted into a reduction in house hold incomes thereby lowering the standards of living in terms of education, health, quality food, housing and other amenities.
- farmers have employed different measures to control the pest such as; Daily field inspection to establish new cases, Cutting and burning infected twigs/branches, Pruning and de-sucking coffee trees, Fertilizer application to ensure soil nutrients, Spraying with systemic pesticides and, Clean weeding.
- Farmers have not controlled the pest through other measures such as: Introduction of natural enemies to the pest, use of traps, and so on. Farmers either lack the knowledge about other control measures, or the measures have not been proven effective enough for farmers to adopt.

Recommendations

The researcher made the following recommendations in order to acknowledge the effect caused by the black coffee twig borer on coffee productivity as to employ appropriate efforts to mitigate the pest.

- First and foremost, all coffee stake holders should understand that coffee is a cornerstone for development and therefore should hit hard to fight this major threat of a black coffee twig borer.
- Sensitization and training of stake holders about the pest should be intensified by extension workers to increase awareness about the pest as well as capacitating farmers with better practices in pest management.
- Better agronomic practices as well as recommended mitigating measures should be employed by coffee farmers to curb down the black coffee twig borer pest which is a threat to coffee.
- Byelaws should be made by local leaders to reprimand those neglecting their plantations to ensure that all fields are clean to reduce all hiding avenues for the pest.
- Government should provide subsides and agricultural loans to coffee dealers to ease them manage the costs of agricultural inputs as well as labor required to curb down the pest.
- Government should arrange for appropriate blanket Spraying regimes with systemic pesticides in order to realize effective control of the pest. This is because farmers may not afford the cost of pesticides as well as the entire spraying exercise.
- Researchers should Introduce resistant varieties that can tolerate the pest.
- Research should be intensified by the ministry of agriculture about introduction of natural enemies to fight the pest. This biological control could be cheap as well as environment friendly.

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