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Implications of Black Coffee Twig Borer on cocoa in Uganda

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Abstract

Cocoa (*Theobroma cacao* L.) is one of Uganda's major cash crops. It is grown by 15,000-18,000 smallholder households on an estimated 20,000 hectares. Cocoa contributes about US$65 million annually to the country's foreign exchange earnings. On account of its perennial nature and robust vegetative growth, cocoa harbors a wide range of insect pests which affect its production. Here, we report for the first time an outbreak of the Black Coffee Twig Borer (BCTB), *Xylosandrus compactus* (Eichhoff), a new pest on cocoa in Uganda. To determine its spread and impact, we surveyed 20 households in Bundibugyo, Kibaale and Hoima districts in January 2014. On each field, 10 cocoa trees were examined for BCTB infestation along a transect. Overall, more than half of the cocoa plantations, 13% of trees and 3.8% of primary branches were infested. At district level, Kibaale had the highest proportions of infested fields (100%), trees (30%) and primary branches (8.5%). The seriousness of BCTB prevalence is likely to complicate the current BCTB spray programme on coffee in the country.

Key words: Cocoa, *Theobroma cacao, Xylosandrus compactus*

Introduction

Cocoa (*Theobroma cacao* L.) is the sixth most important cash crop of Uganda (UBOS, 2012). It is grown by 15,000-18,000 smallholder households on an estimated 20,000 hectares of land scattered in central, mid-western and mid-eastern regions (Jones and Gibbon, 2011). In the 2012/2013 season, the country produced about 19,000 metric tonnes of cocoa beans; fetching an estimated US$ 65 million (Kimera, 2013). Also, being a perennial tree crop, cocoa plays many other ecological roles including atmospheric carbon sequestration and conservation of useful fauna such as pollinators and decomposers (Schroth and Harvey, 2007). It is, therefore, a key crop in eradicating extreme poverty as well as ensuring environmental sustainability.

However, due to its perennial and robust vegetative growth nature, cocoa harbors a wide range of insect pests, including capsids, scales, mealybugs, caterpillars, and, pod and stem borers, among others, that greatly affect its production (Kayobyo *et al.*, 2001). Currently, the advent of a relatively new but serious pest, the Black Coffee Twig Borer (Hereafter referred to as BCTB), *Xylosandrus compactus* Eichhoff (Coleoptera: Curculionidae), has further broadened the pest challenge on the crop

(Kagezi *et al*., 2014a, b, c, d). BCTB is a serious pest of coffee in Uganda (Egonyu *et al*., 2009; Kagezi *et al*., 2012, 2013a, b; UCDA, 2012) and elsewhere (Burbano, 2010), but also infests more than 224 other plant species in about 62 families worldwide, including cocoa (Ngoan *et al*., 1976; Kagezi *et al*., 2012; 2013b, 2014a,b). This pest thus poses a serious threat to both coffee and cocoa production in Uganda, and therefore, calls for prompt comprehensive mitigation actions (Kagezi *et al*., 2013a,b, 2014a,b,c,d).

Damage is caused by the female beetle by boring a characteristic pin-sized entry hole into the attacked seedlings and/or primary branches (twigs), causing them to wilt and eventually die within a few weeks (Ngoan *et al*., 1976). Therefore, the damaged plant parts do not bear fruits resulting into loss of yields and hence, income (Egonyu *et al*., 2009; Kagezi *et al*., 2012; 2013a). BCTB infestation has been reported to be promoted by a number of bio-ecological factors including field and crop management practices (Kagezi *et al*., 2014a,b). Research on coffee shows that BCTB infestation is higher on plants grown under shade (Kucel *et al*., 2011; Kagezi *et al*., 2013c) and on closely planted, un-pruned or inadequately de-suckered plants (Kagezi *et al*., Unpublished data). These conditions probably offer micro-environments that may favor development and completion of its life cycle (Kucel *et al*., 2011; Kagezi *et al*., 2013c) and that of the associated ambrosia fungus (*Wintgens, 2009*). In addition, most of the shade tree and plant species commonly found in cropping systems are alternate host species for BCTB; notably *Albizia chinensis*, *Maesopsis eminii* and *Markhamia lutea* (Kucel *et al*., 2011; Kagezi *et al*., 2012, 2013b, 2014a,b).

However, being a relatively new pest in Uganda, there is generally limited information on biology, ecology, control and the actual yield loss caused by BCTB on several host plants including cocoa and coffee (Kagezi *et al*., 2012, 2013a, b, 2014a, b, c, d). The objectives of this study were therefore: (i) to determine prevalence, damage and impact *X. compactus* on cocoa production in the cocoa agro-ecosystems, and, (ii) to assess field and crop management practices that could promote *X. compactus* infestation.

Materials and methods

Study site

The study was conducted in the Lake Albert Crescent Zone (LACZ) in mid-western Uganda in the cocoa growing districts of Bundibugyo, Hoima and Kibaale, during January 2014. Bundibugyo district is located 00° 27'N, 033° 11'E at 1200 m above sea level (m.a.s.l) (HLGSA-Bundibugyo, 2009); while Hoima district is situated 01°00'-2°00'N and 30°30'-31°45'E, 1158 m.a.s.l. (IFPRI, 2001). Kibaale district lies 00° 58'N, 30° 59'E at 1130 m.a.s.l (HLGSA-Kibaale, 2009). The region is characterised by rainfall in the range of 800-1500 mm per *annum* and temperatures of 15-30 °C (Adur, 2007).

Sample farm selection and data collection

In each district, at least three sub-counties were randomly selected and in each sub-county, at least two parishes were also randomly selected. A total of 20 cocoa plantations were randomly selected for the study. In the selected parish, the sampled plantations were spaced at least 1 Km apart of each other. BCTB infestation was determined on 10 cocoa trees along a diagonal transect. The total number of primary branches as well as those infested was determined. This information was used to compute the percentage of infested cocoa plantations, trees and primary branches for each district. In addition, field and crop management as well as the shade systems were assessed at plot level.

Data analysis

Before analysis, data on the number of primary branches and the percentage of BCTB-infested primary branches were log(X+1) and arcsine transformed respectively in order to reduce non-normality and heterogeneity of variances. These were then compared across the districts using analysis of variance (ANOVA) with general linear model (GLM) procedure of Statistical Analysis System (SAS) software (SAS Institute, 2008). Means were separated by Tukey's test at 5%.

Results

BCTB infestation on cocoa in the LACZ

Overall, more than 50% of the cocoa plantations, 13% of the trees and 3.8% of the primary branches in the study area were infested by BCTB. The percentage of infested plantations, trees and primary branches varied significantly ($p \leq 0.05$) across the sampled districts. The highest percentage of infested plantations (100%), trees (30%; Table 1) and primary branches (8.5%; Table 2) were recorded in Kibaale district.

Field and crop management practices in the LACZ

Poor field and crop management have been reported to promote BCTB infestation in crop species. Table 3 shows the intensity of field and crop management in the sampled districts. In all districts, ≥40% of the cocoa fields were both weeded and mulched. In Bundibugyo and Kibaale districts, at least 20% of the fields were intercropped with coffee, the most preferred host plant species for BCTB. At least 40% of the cocoa fields in Bundibugyo and Kibaale districts were both de-suckered and pruned. On the other hand, 80% of the fields in Hoima were neither de-suckered nor pruned.

Cocoa agroforestry systems in the LACZ

Similarly, agroforestry systems have been reported to favour BCTB infestation in crop species. In Bundibugyo and Kibaale districts, at least 70% of the cocoa plantations had low levels of shading, whereas in Hoima district, 40% of the plantations were either moderately or highly shaded (Fig. 1). Overall, 26 shade tree and shrub species were recorded in the cocoa systems in the region. Nile tulip tree (*Markhamia lutea*; 85%), and,

Table 1. Percentage of cocoa farms and trees infested by the Black Coffee Twig Borer (BCTB), *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in the Lake Albert Crescent zone (LACZ), Uganda

District	Infested cocoa farms (%)	Infested cocoa trees (%)
Bundibugyo	30.0	8.0
Hoima	**60.0**	6.0
Kibaale	**100.0**	30.0
X^2	38.9474	24.18
DF	2	2
P value	<.0001	<.0001

Values ≥50% are in bold.

Table 2. Number of primary branches and those infested by the Black Coffee Twig Borer (BCTB), *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in the Lake Albert Crescent zone (LACZ), Uganda

District	Number of primary branches	Infested primary branches (%)
Bundibugyo	1.1±0.2 (14.8±5.5) a	0.9±1.2 (3.1±13.7) b
Hoima	1.1±0.2 (13.0±5.4) ab	0.7±0.5 (0.7±2.6) b
Kibaale	1.0±0.3 (11.9±6.2) b	1.6±1.8 (8.5±17.9) a
CV	16.91	125.65
P value	8.07**	7.93**

Same letters within a column indicate means (after log(X+1) and arcsine transformation respectively) are not significantly different by Tukey's test (*P≤0.05). Values in parenthesis are the untransformed means.

Table 3. Field and crop management practices on cocoa farms in the Lake Albert Crescent zone (LACZ), Uganda

Intensity of management practice	District		
	Bundibugyo (%)	Hoima (%)	Kibaale (%)
Weeding			
Low	0	0	20
Moderate	20	40	40
High	**80**	**60**	40
Mulching			
Low	10	0	20
Moderate	10	0	20
High	**80**	**100**	**60**
Intercropped with coffee			
Yes	40	0	20
De-suckering			
No	30	**80**	20
Low	30	0	20
Moderate	40	20	**60**
Pruning			
No	10	**80**	0
Low	30	0	4
Moderate	**60**	20	40
High	0	0	20

Values ≥50% are in bold

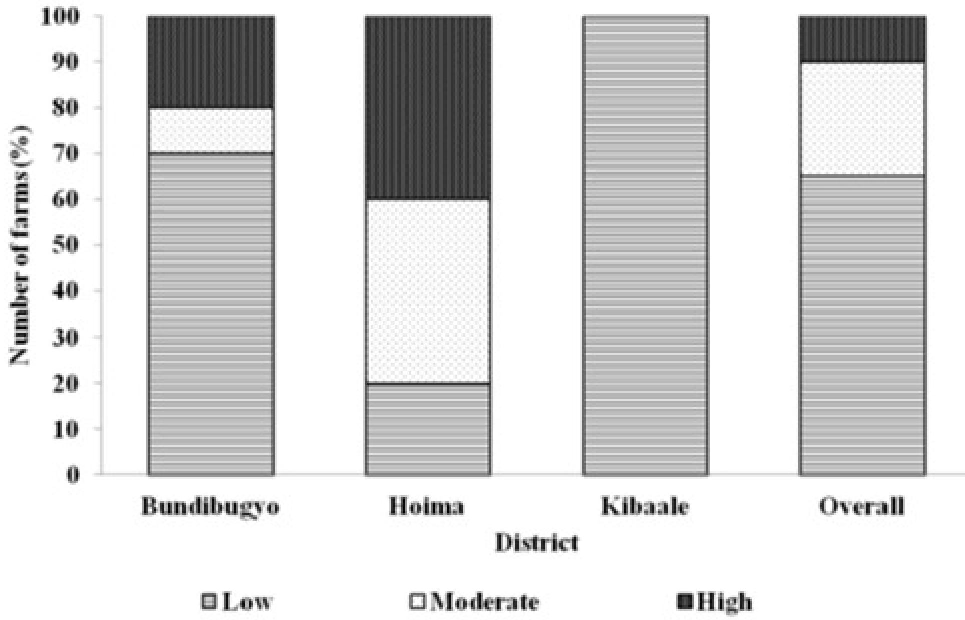

Figure 1. Intensity of shade systems in cocoa plantations in the Lake Albert Crescent zone (LACZ), Uganda.

avocado (*Persea Americana*), umbrella tree (*Maesopsis eminii*) and jackfruit (*Artocarpus heterophyllus*; 40%) were the commonest species (Table 4).

Discussion

The Black Coffee Twig Borer (BCTB), *Xylosandrous compactus* Eicchoff is a relatively new pest in Uganda. It was initially reported on Robusta coffee (Egonyu *et al*., 2009) but, currently it is known to attack more than 40 plant species in Uganda including cocoa (Kagezi *et al*., 2012, 2013b, 2014a, b, c). In Uganda, BCTB was first observed infesting cocoa on seedlings in screen-house experiments at the National Coffee Research Institute (NaCORI), Kituza in 2011 (Kagezi *et al*., 2012; 2013b). Subsequently, in December 2013, extension staff in Harugale sub-county, Bundibugyo district reported severe wilting of cocoa, attributing it to Verticillium wilt (Kayobyo *et al*., 2001). However, research later confirmed presence of BCTB-characteristic damage symptoms on the wilting branches and small stems (Kagezi *et al*., 2014c, d). This is in agreement with findings of studies conducted elsewhere (Subaharan *et al*., 2008).

Our results showed that the percentage of BCTB-infested cocoa plantations, trees and primary branches varied significantly ($P \leq 0.05$) across the districts (Tables 1, 2); with the highest infestation being recorded in Kibaale district. This is in line with the results of a survey conducted in the region in 2012/13 which showed higher infestation levels of BCTB on coffee in Kibaale compared to other districts in the LACZ (Kagezi *et al*., 2013a). This finding could in part be attributed to the recent high levels of deforestation in Kibaale district, owing to increase in human population (Christensen and Jensen, 2011). This could have led to the depletion of alternative host plant species for BCTB

Table 4. Trees (%) observed in the cocoa systems in the Lake Albert Crescent zone (LACZ), Uganda. Values ≥50% are in bold

Family	Scientific name	Common name	Local name (Luganda)	Bundibugyo (%)	Hoima (%)	Kibaale (%)	Overall (%)
Bignoniaceae	*Markhamia lutea* (Benth.) K.Schum.	Nile tulip tree	Musambya	**90**	**100**	40	**85**
Lauraceae	*Persea americana* Mill.	Avocado	Ovakeddo	30	40	**60**	40
Rhamnaceae	*Maesopsis eminii* Engl.	Umbrella tree	Musizi	40	0	**60**	40
Moraceae	*Artocarpus heterophyllus* Lam.	Jackfruit	Ffene	40	40	40	40
Fabaceaea	*Senna spectabilis* (DC.) Irwin & Barneby	Cassia	Gasiya	30	20	40	30
Anacardiaceae	*Mangifera indica* L.	Mango	Muyembe	30	40	20	30
Caricaceae	*Carica papaya* L.	Paw paw	Papaali	30	20	0	20
Asteraceae	*Vernonia* amygdalina Delile	Bitter leaf	Mululuza	20	20	20	20
Arecaceae	*Elaeis guineensis*	African oil palm	Munazi	20	0	0	15
Rutaceae	*Citrus sinensis* (L.) Osbeck	Citrus	Mucungwa	10	20	0	15
Moraceae	*Ficus natalensis* Hochst.	Natal Fig, Back-cloth Fig	Mutuba	10	0	20	15
Moringaceae	*Moringa oleifera*	Horseradish tree	Muringa	10	0	0	10
Myrtaceae	*Callistemon* spp.	Bottlebrush	-	10	0	0	10
Fabaceae	*Albizia coriaria* Oliv.	-	Mugavu	10	20	0	10
Moraceae	*Ficus sycomorous*	Sycamore fig, Fig-mulberry	Mukunyu	10	20	0	10
Euphorbiaceae	*Ricinus communis* L.	Castor oil	Nsogasoga	0	40	0	10
Myrtaceae	*Psidium guajava* L.	Guava	Peera	10	0	0	5
Boraginaceae	*Cordia africana* Lam.	Mringaringa	Mukebu	10	0	0	5
Proteaceae	*Grevillea robusta* A. Cunn. ex R.Br.	Silky oak	Kalwenda	10	0	0	5
Rosaceae	*Prunus africana*	Red Stinkwood, African Plum	Ntasesa, ngwabuzito	10	0	0	5
Combretaceae	*Terminalia mantaly* H. Perrier	Umbrella tree	Muyati	0	0	0	5
Moraceae	*Milicia excelsa* (Welw.) C.C. Berg	African Teak	Muvule	0	0	20	5
Euphorbiaceae	*Sapium ellipticum* Pax	Jumping seed tree	Musasa	0	20	0	5
Moraceae	*Ficus exasperata* Vahl.	Sandpaper tree	Luwawu	0	20	0	5
Fabaceae	*Acacia* spp.	Acacia, whistling thorn	Kasana	0	20	0	5
Bignoniaceae	*Spathodea campanulata* P. Beauv.	African tulip tree	Kifabakazi	0	20	0	5

from the wild, thus causing the beetle to seek for new ecological niches on cocoa (Kekeunou *et al*., 2006). In the natural forests, pest damage is generally limited (Nair *et al*., 1986). However, deforestation destroys the ecological niches contributing to the rupture of the existing stable biological balance and favours the pest population outbreak (Kekeunou *et al*., 2005). BCTB has been reported to attack a number of forest tree and shrub species in Uganda (Kagezi *et al*., 2012, 2013b, 2014a, b) and elsewhere (Ngoan *et al*., 1976). However, this pest seems not to be highly host specific in its natural mixed-forest habitat, and it is only when it finds special conditions of concentrated cultivation that it tends to become a pest (Browne, 1961). Secondly, recently, the Uganda Coffee Development Authority (UCDA) and local extension have been spearheading an extensive strategy of using cultural combined with chemical measures to control BCTB on coffee in the region. This could have led to a change in its ecological niche from coffee to cocoa (Kekeunou *et al*., 2006).

Consequently, the emergence and/or resurgence of BCTB in Uganda poses a very serious threat not only to coffee (Egonyu *et al*., 2009; Kagezi *et al*., 2013a,b, 2014a,b), but also to cocoa production (Kagezi *et al*., 2014c,d). This therefore calls for comprehensive mitigation measures to be implemented before the situation gets out of hand. It should also be noted that the Lake Albert Crescent Zone (LACZ) produces the bulk of Uganda's cocoa (ADC/IDEA, 1998, 2000; Jones and Gibbon, 2011; Kimera, 2013). This emphasizes the economic importance posed by this pest to the country's cocoa industry. The adverse effects due to this pest will, therefore, not only be detrimental to the national coffers, but also to the 15,000-18,000 smallholder householders who derive their livelihood from various cocoa activities along the value chain (Jones and Gibbon, 2011; Kimera, 2013). In addition, this pest threatens to roll back efforts by the government and the private sector to revamp cocoa production in the country (Kimera, 2013; Kagezi *et al*., 2014c, d). This outbreak is also likely to complicate the Uganda Coffee Development Authority (UCDA)-led BCTB spray campaign on coffee in this region (Kagezi *et al*., 2014c, d).

Field management practices may create variations in conditions that might favour or disfavour multiplication and development of various insect pests including BCTB (Kucel *et al*., 2009; Kagezi *et al*., 2014a, b). Our results showed that the cocoa fields in all districts were generally weeded as well as mulched. Weeding and mulching suppress weeds which would have competed with cocoa plants for nutrients, space, moisture and light (Nair, 2010); at the same time mulching also improves moisture retention in the system (Wintgens, 2009). This promotes plant vigor and therefore may help in improving the ability of the cocoa trees in resisting BCTB infestation or recovering from infestation (Jones and Johnson, 1996). Research shows that plants are usually most susceptible when they are stressed, for example, during times of drought when they are recieving limited moisture and nutrients (Jones and Johnson, 1996; Smith, 2003). In addition, results of this study showed that at least 20% of the cocoa were intercropped with coffee in Bundibugyo and Kibaale districts whereas, all the cocoa in Hoima district had no coffee. This presents a lot of implications in regard to managing BCTB since coffee is the most preferred host plant species for the pest (Egonyu *et al.*, 2009; Kagezi *et al.*, 2012, 2013b, 2014a, b). This implies that cocoa intercropped with BCTB-infested coffee is more likely to be invaded due to the proximity of the source of infestation.

Crop management is also important in the bio-ecology of BCTB (Kagezi *et al.*, 2014a, b). Results of the present study showed that most (≥70%) of the cocoa plants in Bundibugyo and Kibaale districts were both de-suckered and pruned. However, in Hoima district, 80% of them were neither de-suckered nor pruned. Research conducted in Uganda shows higher BCTB infestation on coffee grown under bushy conditions; that is, closely planted, un-pruned or inadequately de-suckered plants (Kagezi *et al.*, Unpublished data). These conditions probably promote micro-environments that may favour development and completion of the life cycle of BCTB (Kucel *et al.*, 2011; Kagezi *et al.*, 2014a, b) as well as that of its associated ambrosia fungus (*Wintgens, 2009*). Thus, both practices help in removing excess stems, branches and suckers (Kayobyo *et al.*, 2001) which would have created the above-mentioned conditions (Kagezi *et al.*, 2014a, b).

Shade systems have also been reported to promote its infestation on coffee (Anuar, 1986; Kucel *et al.*, 2011; Kagezi *et al.*, 2013c), which could also be true for cocoa. Our study showed that at least 70% of the cocoa farms in Bundibugyo and Kibaale districts were under low levels of shading; but 40% of the fields in Hoima district were under high intensity shade. As with bushiness, shadiness also offers favorable micro-environments for development of BCTB and its associated ambrosia fungus (*Wintgens, 2009;* Kucel *et al.*, 2011; Kagezi *et al.*, 2014a, b). In addition, the most observed tree species in this study (*Markhamia lutea, Persea Americana, Maesopsis eminii* and *Artocarpus heterophyllus*) have been reported to be some of the most preferred alternate host plant species for BCTB (Kagezi *et al.*, 2012, 2013b,c, 2014a,b,c,d). In the light of the outbreak of BCTB therefore, farmers need to make the right choice of the shade trees to be planted in their cocoa or coffee (Kagezi *et al.*, 2013b, c). In addition, shade management should be carried regularly to preclude infestations or to serve as a cultural control strategy to lessen damage by BCTB when infestations are already present (Anuar, 1986; Kagezi *et al.*, 2013c).

Conclusion

Our study found extensive damage by BCTB in cocoa fields for the first time in Uganda; with the highest infestation levels being observed in Kibaale district. The outbreak of this pest therefore poses a serious threat to cocoa production in Uganda if no comprehensive mitigation measures are put in place. This might also complicate the BCTB spray programme on coffee campaign in this zone. Thus, there is a need to institute appropriate containment actions as well as derive an appropriate research agenda to mitigate the pandemic. We therefore recommend that a more comprehensive survey be conducted in all major cocoa producing zones to determine the actual national spread and impact levels. Also, the current UCDA implemented BCTB spray-programme for coffee in the mid-western region should be re-evaluated in light of these new developments on cocoa.

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References

ADC/IDEA. 1998. A baseline survey on cocoa production in selected districts of Uganda. Final report for ADC/ IDEA Project. 109 pp.

ADC/IDEA. 2000. The situation of cocoa production in Uganda. First consultancy progress report for the ADC/IDEA Project, CIRAD-Cocoa programme, Uganda. 19 pp.

Adur, S.E. 2007. Production characteristics: A case of smallholder farmers in Hoima district, Uganda. *African Crop Science Conference Proceedings* 8:1323-1327.

Anuar, A.M. 1986. Observation on damage by *Xylosandrus compactus* in coffee as affected by shade and variety, *MARDI Research Bulletin* 14(2):108-110.

Browne, F.G. 1961. The biology of Malayan Scolytidae and Platypodidae. *Malayan Forest Records* 22:255.

Burbano, E.G. 2010. Developing a monitoring tool to understand the seasonal dynamics and management techniques estimate a sampling plan for *Xylosandrus compactus (*Eichhoff) in Hawaii. Ph.D. Dissertation. University of Hawaii at Manoa, HI, USA.

Christensen, J. and Jensen, S.S. 2011. The tragedy of private forestry. Understanding deforestation of private natural forests in Kibaale district, Uganda. MSc. Thesis. Aalborg University, Denmark.

Egonyu, J.P., Kucel, P., Kangire, A., Sewaya, F. and Nkungwa, C. 2009. Impact of the black twig borer on Robusta coffee in Mukono and Kayunga districts, central Uganda, *Journal of Animal and Plant Sciences* 2(4):163-169.

HLGSA Bundibugyo. 2009. Higher Local Government Statistical Abstract, Bundibugyo district. http://www.ubos.org/onlinefiles/uploads/ubos/2009HLG%20 Abstract printed/Bundibugyo%20DLG%20Abstract%20%202009-final.pdf. Last accessed on May 12, 2014.

HLGSA Kibaale. 2009. Higher Local Government Statistical Abstract, Kibaale district. http://www.ubos.org/onlinefiles/uploads/ubos/2009 HLG %20 Abstract printed/Kibaale%20District%202009%20Statistical%20Abstract%20 Edited .pdf. Last accessed on May 14, 2014.

IFPRI. 2001. Background Information on Masindi, Kabarole and Hoima Districts. Prepared for Strategic Criteria for Rural Investments in Productivity (SCRIP) project. Kampala, Uganda: International Food Policy Research Institute. 11 pp.

Jones, E.S. and Gibbon, P. 2011. Developing agricultural markets in Sub-Saharan Africa: Organic cocoa in rural Uganda. *Journal of Development Studies* 47(10):1595-1618.

Jones, V.P. and Johnson, M.V. 1996. Management of black twig borer on coffee. Unpublished report to Governor's Agriculture Coordinating Committee, CTAHR, University of Hawaii, Honolulu.

Kagezi, G.H., Kucel, P., Egonyu, J.P., Kyamanywa, S., Karungi, J.T., Pinard, F., Jaramillo, J., van Asten, P., Wagoire, W.W. and Ngabirano, H. 2014a. Management of the Black Coffee Twig Borer, *Xylosandrus compactus*

(Eichhoff) in Uganda. 54th Inter-African Coffee Organisation (IACO) Annual General Assembly and 2nd African Coffee symposium. 17th-21st November 2014, Kampala, Uganda.

Kagezi, G.H., Kucel, P., Egonyu, J.P., Kyamanywa, S., Karungi, J.T., Pinard, F., Jaramillo, J,, van Asten, P., Wagoire, WW. and Ngabirano, H. 2014b. A review of the pest status and research progress on the black coffee twig borer, *Xylosandrus compactus* (Eichhoff) in Uganda. 25th International Conference on Coffee Science (ASIC 2014), Colombia, 8th - 13th September 2014.

Kagezi, G.H., Kucel, P., Egonyu, P.J., Nakibuule, L., Kobusinge, J., Ahumuza, G., Matovu, R.J., Nakendo, S., Luzinda, H., Musoli, C.P., Kangire, A. and Chesang, B.F. 2013a. Impact and farmers' coping mechanisms of the Black Coffee twig borer, *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in Uganda. Proceedings of 11th African Crop Science Society Conference, 2013.

Kagezi, G.H., Kucel, P., Kobusingye, J., Nakibuule, L., Wekhaso, R., Ahumuza, G., Musoli, P. and Kangire, A. 2013c. Influence of shade systems on spatial distribution and infestation of the Black Coffee Twig Borer on coffee in Uganda. *Uganda Journal of Agricultural Sciences* 14 (1):1-12.

Kagezi, G.H., Kucel, P., Mukasa, D., van Asten, P., Musoli, P. and Kangire, A. 2012. Pest status, damage and host plant utilization of the Black Coffee Twig Borer (BCTB), *Xylosandrus compactus* Eichhoff (Coleoptera: Curculionidae) in Uganda. The 24th International Conference on Coffee Science, ASIC. November 11-16, 2012, San José, Costa Rica.

Kagezi, G.H., Kucel, P., Mukasa, D., van Asten, P., Musoli, P.C. and Kangire, A. 2013b. Preliminary report on the status and host plant utilization by the Black Coffee Twig Borer, *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in Uganda. Proceedings of the 24th International Conference on Coffee Science, ASIC, San José, Costa Rica November 11-16, 2012. pp. 1323-1326.

Kagezi, G.H., Kucel, P., Nakibuule, L. and Kobusinge, J. 2014c. Back to office report: Survey in the coffee-banana-agroforestry systems of south-western Uganda, December 12-23, 2013. 9 pp.

Kagezi, G.H., Kucel, P., Egonyu, J.P., Ahumuza, G., Nakibuule, L., Kobusinge, J. and Wagoire, W.W. 2014d. Black Coffee Twig Borer, *Xylosandrus compactus* (Eichhoff) on cocoa (*Theobroma cacao* L.) in Uganda: A first report and its implications. 2nd Biennial NARO Scientific Conference, 3rd–7th November 2014, Entebbe, Uganda.

Kayobyo, G., Hakiza, G.J. and Kucel, P. 2001. Cocoa (*Theobroma cacoa)*. In: Mukiibi, J.K. (Ed.).Agriculture in Uganda Vol. II. Fountain Publishers/ CTA/NARO. pp. 462-486.

Kekeunou, S., Messi, J., Foahom, B. and Weise, S. 2005. Impact of forest cover degradation on diversity and pest status of grasshoppers in Africa. *International Forestry Review* 7(5):391.

Kekeunou, S., Messi, J., Weise, S. and Tindo, M. 2006. Insect pests' incidence and variations due to forest landscape degradation in the humid forest zone of Southern Cameroon: farmers' perception and need for adopting an integrated pest management strategy. *African Journal of Biotechnology* 5(7):555-562.

Kimera, J. 2013. Uganda sees its 2013/ 2014 cocoa output rising 26 percent. http://www.newvision.co.ug/news/ 649626-uganda-sees-its-2013-2014-cocoa-output-rising -26 percent.html. Last accessed on February 02, 2014.

Kucel, P., Egonyu, J.P., Kagezi, G. and Musoli, P.C. 2011. Shade and varietal effects on diversity and prevalence of insect pests of Robusta coffee in central Uganda. CAFNET end of project report. 10pp.

Kucel, P., Kangire, A. and Egonyu, J.P. 2009. Status and current research strategies for management of the coffee berry borer (*Hypothenemus hampei* Ferr) in Africa. ICO Seminar on the Coffee Berry Borer. http:// dev.ico.org/eventpdfs/cbb/ presentations /Kangire%20 NaCRRI. pdf. Last accessed on November 24, 2011.

Nair, K.S.S., Mathew, G., Mohanadas, K. and Menon, A.R.R. 1986. A study of insect pest incidence in natural forests. KFRI Research Report 44. December 1986. 32pp.

Nair, P.K.P. 2010. The agronomy and economy of important tree crops of the developing world. 1st edition. Amsterdam, Boston, USA. 351 p.

Ngoan, N.D., Wilknison, R.C., Short, D.E., Moses, C.S. and Mangold, J.R. 1976. Biology of an introduced Ambrosia beetle, *Xylosandrus compactus* in Florida. *Annals of the Entomological society of America* 69(5):872-876.

SAS Institute. 2008. SAS/STAT Software: Version 9.2, SAS Institute Inc., SAS Campus Drive, Cary, North Carolina 27513.

Schroth, G. and Harvey, C.A. 2007. Biodiversity conservation in cocoa production landscapes: an overview. *Biodiversity and Conservation* 16(8):2237-2244.

Smith, V.E. 2003. Coffee twig borer infestation increases in stressed plants. West Hawaii Today. *Sect* A:30.

Subaharan, K., Kannan, C., RohiniIyer and Vidyasagar, P.S.P. 2008. Incidence of shot hole borer, *Xylosandrus compactus* Eichhoff on wilt disease affected cocoa. *Entomon* 1:87-88.

UBOS, 2012. Uganda Bureau of Statistics (UBOS). Statistical Abstract. June 2012. http://www.ubos.org/onlinefiles/ uploads/ubos/pdf%20documents/ 2012StatisticalAbstract.pdf. Last accessed on May 30, 2014.

UCDA. 2012. UCDA's guidance on the Coffee Twig Borer (CTB). Uganda Coffee Development Authority (UCDA). http://www.agricultural reviewonline.com/indexphp/ featured/ 68-featured/ 125-ucdas-guidance-on-the-coffee-twig-borerctb.html. Last accessed on July 14, 2012.

Wintgens, J.N. 2009. Coffee: Growing, processing, sustainable production: A guide book for growers, processors, traders, and researchers, 2nd Edition. Wiley-VCH Verlag GmbH. 1040 pp.