ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 4
November 2019
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

*Afr. J. Food Agric. Nutr. Dev.* 2019; 19(4): 14863-14872 DOI: 10.18697/ajfand.87.17725

# PESTICIDES USED BY FARMERS IN THE ARABICA COFFEE GROWING REGIONS OF UGANDA

**Kagezi GH[1*], Kucel P[1], Olango N[1], Kobusinge J[1], Nakibuule L[1], Nambozo B[1], Olal S[1] and WW Wagoire[1]**

**Godfrey H. Kagezi**

*Corresponding author email: gkagezi@gmail.com

[1]National Coffee Research Institute (NaCORI)/National Agricultural Research Organisation (NARO). P.O. BOX 185, Mukono, Uganda.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 4 November 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

**ABSTRACT**

Coffee is generally stressed by several biotic constraints including insect pests, diseases, weeds, nematodes among others, due to its nature. In response, farmers use all sorts of pesticides so as to manage these problems. However, detailed studies to determine the types of pesticides used in the diverse Arabica coffee agro-ecologies of Uganda are yet to be conducted. This information is vital for guiding research, policy and other agendas on pesticide issues, since their misuse can cause serious negative effects on humans, livestock and environment. A questionnaire was therefore, administered to 325 households in the 3 major Arabica coffee growing regions of Uganda (Mt. Elgon, West Nile and southern), with the aim of determining which pesticides are commonly being used by farmers. The study specifically aimed at investigating which pesticides have been banned in Uganda but still being used by farmers in these Arabica coffee agro-ecologies. Results showed that pesticides use in the Arabica coffee growing regions of Uganda was limited, with only 23% of the farmers using them. The highest percentage of farmers (39%) using pesticides was recorded in the southern region, while the lowest percentage of farmers (11%) was observed in West Nile region. A total of 22 of pesticides namely, 13 insecticides (59%), 5 fungicides (23%) and 4 herbicides (18%) were being used by farmers. Most of the pesticides recorded (64%) belonged to class II chemicals which are defined as moderately hazardous. Farmers should, therefore, be encouraged to use these pesticides instead of the class I chemicals which are defined as highly hazardous. The commonest insecticide was cypermethrin, being used by 15.4% of the farmers, while mancozeb was the most common fungicide, used by 7.7%. On the other hand, glyphosate was the most commonly used herbicide, by 15.4% of the farmers. The study further revealed that three insecticides - carbofuran (Furadan 5), dichlorvos 100% (Lava 100% EC) and fenitrothion (Sumithion/Fenitrothion) and one herbicide, gramoxone (Paraquat), which were being used by farmers, have been banned from use in Uganda. However, none of the fungicides observed has been banned from use in Uganda. Thus, farmers in all coffee growing agro-ecologies should be educated on pesticide use particularly those that have been banned from use. This will reduce pesticide misuse, toxicity and exposure.

**Key words**: Arabica-coffee-agro-ecologies, banned-pesticides, carbofuran, cypermethrin, dichlorvos, fenitrothin, glyphoshate, gramoxone, mancozeb, pesticide-use

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 4 November 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

## INTRODUCTION

Coffee remains the main cash crop of Uganda. It earned the country about US$370 million in the coffee year 2015/16 in exports [1]. The crop is grown by more than 1.3 million households (of which a quarter are female-headed) with more than 5 million Ugandans deriving their livelihood from coffee-related activities along the value chain [2]. Coffee also contributes to food security since farmers use the proceeds from its sales to cater for their daily needs (such as medical care, education, house improvement among others) instead of selling their food crops. In addition, being a perennial crop, it plays many other important ecological roles, such as reducing atmospheric carbon dioxide concentration and conserving useful fauna such as pollinators. It is, therefore, a key crop in eradicating extreme poverty and hunger, as well as protecting, restoring and promoting sustainable use of terrestrial ecosystems – the 1st, 2nd, 13th and 16th Sustainable Development Goals (SDG's) (sustainabledevelopment.un.org).

Farmers in Uganda grow two types of coffee – Robusta coffee which contributes about 80% of the coffee volumes and Arabica coffee which accounts for the other 20% [1, 3]. Arabica coffee is mainly grown in the high altitude areas of the country (above 1500 meters above sea level, masl) – particularly in the Mt Elgon and Sebei regions, South western and West Nile regions of Uganda [3]. Despite its importance to the livelihoods of many Ugandans, production of coffee is constrained by a number of biotic stresses such as insect pests, diseases, weeds, nematodes among others [3, 4]. This forces the farmers to use all kinds of pesticides – insecticides, fungicides, nematicides and herbicides in order to manage these biotic stresses [4, 5].

However, detailed studies on the types of pesticides used by farmers in the diverse coffee agro-ecologies and how farmers use them are yet to be conducted [6]. This information is vital for guiding research, policy and other agendas on pesticide issues, since their misuse can cause serious negative effects on humans, livestock and environment [5]. In addition, some of these pesticides have been banned from being used in Uganda [7]. Several studies have shown that farmers have limited or no information on type of pesticides they are using and how they should be used [4, 5, 8, 9]. This is coupled with poor handling, and storage as well as disposal of unused pesticides [10].

A study to determine the types of pesticides used by farmers was, therefore, conducted in the main Arabica coffee growing regions of Uganda in 2017. Specifically, this study was aimed at establishing the types of pesticides used in Uganda and to identify those that have been banned but still being used by farmers.

## MATERIALS AND METHODS

The study was conducted in three (3) districts randomly selected in each of the major Arabica coffee growing regions of Uganda - Mt. Elgon (Kapchorwa, Manafwa and Sironko districts), West Nile (Arua, Nebbi and Zombo districts) and Southern (Ibanda, Kisoro and Mitooma districts) Fig. 1.

ajfand SCHOLARLY, PEER REVIEWED
AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT
Volume 19 No. 4
November 2019
PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST
ISSN 1684 5374

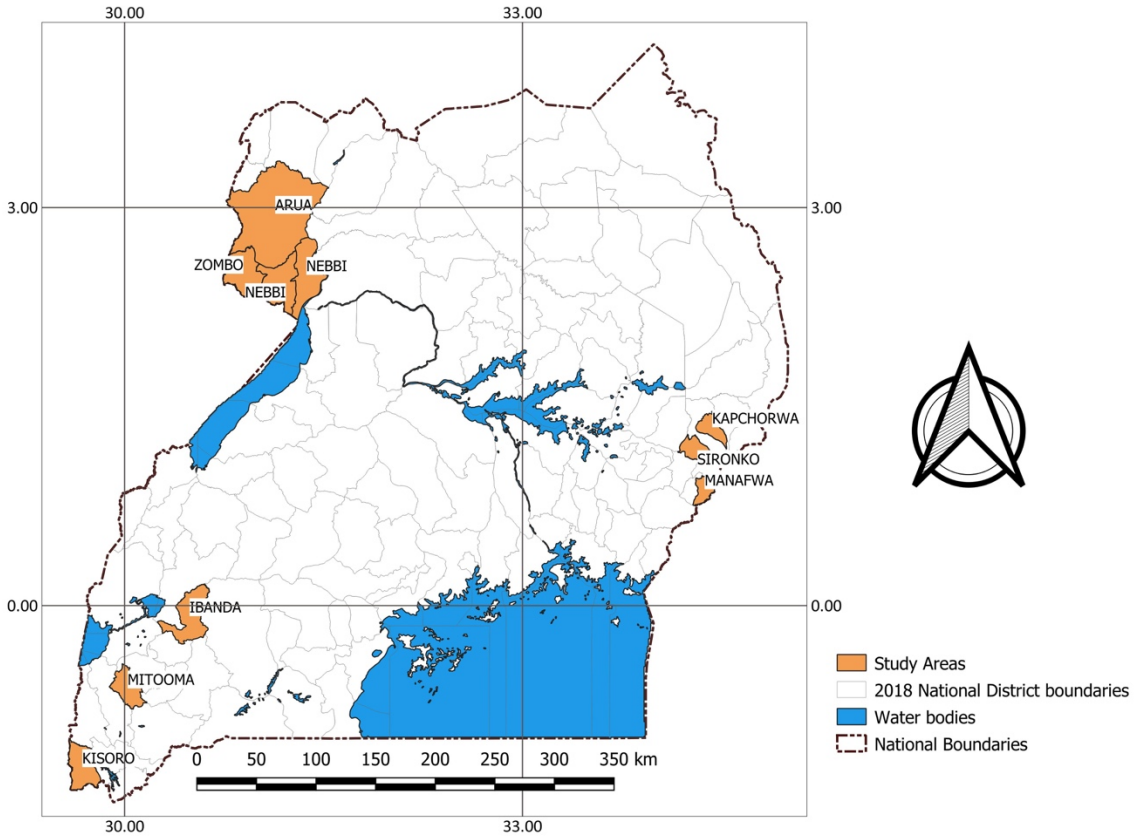


**Figure 1: Location of the study areas within Uganda and the districts of the study areas**

A total of 40 households (where applicable) were targeted to be selected randomly irrespective of the size of their coffee gardens or their economic status using the sampling procedure described above. However, it should be noted that in some districts it was not possible to get the required number. Thus, in total, 325 households were selected as follows: - Kapchorwa (40), Manafwa (38) and Sironko (38) in Mt. Elgon region, Ibanda (40), Kisoro (14) and Mitooma (40) in southern region, and, Arua (34), Nebbi (41) and Zombo (39) in West Nile region.

A short data collection tool to capture the type of pesticides that were being used by the Arabica coffee growing farmers was administered to the selected households. In case a farmer had a container of a pesticide, he/she was requested to show it to the researcher. The percentage of farmers using pesticides was calculated based on the total number of farmers interviewed in the district/region. The pesticides were categorized into Classes (I-IV) according to FAO/WHO [11] and their status of use in Uganda was defined basing on the presentation by the Ministry of Agriculture, Animal Industry and Fisheries (MAAIF) of Uganda [7]. Data were summarized using descriptive statistics including means and percentages.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 4 November 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

## RESULTS AND DISCUSSION

This study determined the pesticides used by farmers in the diverse Arabica coffee growing regions of Uganda. It specifically aimed at establishing the pesticides that have been banned from use in Uganda but still being used by farmers. Results revealed that pesticides use in the Arabica growing regions of Uganda was generally limited with only 23% of the interviewed farmers using the pesticides (Table 1). This finding agrees with earlier reports of low use of pesticides in Arabica coffee systems of Mt. Elgon region, Uganda [6] as well as in the Robusta coffee agro-ecologies of Uganda [12, 13]. Although the data collection tool used in this study did not capture information on why there was low use of pesticides, related studies among horticultural farmers in Uganda [5, 14] and Tanzania [15] implicate the high costs involved. The highest percentage (40%) of farmers using pesticides was recorded in Southern region. Similarly, a study of pesticides use and knowledge of smallholder potato farmers in Uganda showed that pesticides use was highest in this region compared to other parts of the country [9].

A total of 22 pesticides - 13 insecticides (59%), 5 fungicides (23%) and 4 herbicides (18%) were being used by farmers in the study area (Tables 2). This number falls within the ranges of pesticides also reported in horticultural studies conducted in Uganda [8, 9] and other East African countries [15, 16, 17] as well as West African countries [18]. Insecticides were the most commonly used pesticides, representing 59% of the total pesticides observed in the study area. This finding is in agreement with other studies [6, 8, 15, 16, 17, 19]. This is in part due to the fact that farmers often fail to differentiate between damage caused by insects and fungal diseases and, therefore, apply insecticides to control the diseases. This phenomenon was also observed by Liebig T *et al.* [6] in Arabica coffee agro-ecologies of Mt. Elgon. Most (64%) of the observed pesticides belonged to class II chemicals (Table 2) which are defined as moderately hazardous [11]. Similarly, several studies conducted in Uganda [8, 9] and elsewhere [10, 15, 16, 17] have reported that the majority of the farmers interviewed were using moderately hazardous pesticides. This finding is vital information for designing effective IPM options for managing pests as well as pesticide use in developing countries like Uganda [5]. Farmers should be encouraged to adopt these pesticides instead of the class I chemicals which are defined as highly hazardous [11].

Cypermethrin was the most commonly used insecticide in the study area – by 15.4% of the interviewed farmers who were using pesticides (Table 2). This insecticide is cheap and readily available to farmers – making it familiar with many farmers in Uganda [8, 9, 19] as well as in other East African countries [15]. It is worth noting that three of the insecticides, namely carbofuran (Furadan 5), dichlorvos 100% (Lava 100% EC) and fenitrothion (Sumithion/Fenitrothion) have been banned from use in Uganda [7]. Incidentally, these pesticides happen to be common in farming communities in Uganda [4, 5, 6, 9] and elsewhere [15]. For example, Liebig T *et al.* [6] reported that fenitrothion was the most widely used insecticide in Arabica coffee agro-ecologies of Mt Elgon. These insecticides have side effects on human beings – carbofuran burns the skin/eye, dichlorvos causes paralysis whereas, fenitrothion is an anticholinesterase compound [7]. However, although abamectin and acelamiprin (Dudu Accelamectin)

belong to class Ib pesticides (highly hazardous), they are not on the list of banned pesticides in Uganda [7].

On the other hand, mancozeb was the commonest fungicide used by Arabica coffee farmers - by 7.7% of the farmers who were using pesticides (Table 2). This fungicide is very common with horticulture farmers in Uganda [8, 9, 19, 20] and elsewhere [15, 17] because it is generally cheap and readily available [21]. However, none of the fungicides observed in the study area happens to be on list of banned chemicals in Uganda [7]. This corroborates with various reports [8, 9, 15, 17].

For the herbicides, glyphosate was the most commonly used - by 15.4% of the farmers who were using pesticides (Table 2). Similarly, this chemical has been reported to be the commonest herbicide in horticultural production systems in Uganda [8, 9] and elsewhere [22]. Glyphosate is a non-selective herbicide usually used as a labor-saving input in place of hand weeding by farmers in Uganda [23]. One of the herbicides that was being used by farmers – gramoxone has been banned in Uganda [7]. However, this herbicide is still common in Uganda [8] and elsewhere [17, 22]. Gramoxone is highly poisonous and has been linked to suicide cases [7].

## CONCLUSIONS

The study established that pesticide use in the Arabica coffee growing agro-ecologies of Uganda was limited – with only 23% of the farmers using them. A total of 22 types of pesticides, that is 13 insecticides (59%), 5 fungicides (23%) and 4 herbicides (18%) were being used by farmers. The commonest used pesticides were: - cypermethrin (insecticide), mancozeb (fungicide) and glyphosate (herbicide). Four pesticides, carbofuran, dichlorvos, fenitrothion (insecticides) and gramoxone (herbicide) have been banned from use in Uganda. However, none of the fungicides observed has been banned from use in Uganda. It is, therefore, recommended that policy, led by extension and research, should design a well-targeted training program for the farmers on pesticide use, particularly those that have been banned from use. This will reduce pesticide misuse, toxicity and exposure. Secondly, a similar study in the Robusta coffee growing regions of Uganda should be conducted, so as to derive a more comprehensive status of pesticide use in the country.

## FUNDING

This study was fully funded by Café Africa, Uganda - the authors appreciate this support.

## ACKNOWLEDGEMENTS

We acknowledge the staff of the Coffee Cocoa Plant Heath Program of NaCORI who assisted in data collection. The participating farmers, Uganda Coffee Development Authority (UCDA) and the other extension staff are also highly appreciated.

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 4 November 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

**Table1: Percentage of farmers using pesticides in the Arabica coffee growing regions of Uganda**

| Region | District | Farmers (%) | N |
|---|---|---|---|
| Mt. Elgon | Kapchorwa | 25.0 | 40 |
| | Manafwa | 17.9 | 39 |
| | Sironko | 13.2 | 38 |
| *Regional mean* | | *18.7* | *117* |
| Southwestern | Ibanda | 60.0 | 40 |
| | Kisoro | 14.3 | 14 |
| | Mitooma | 42.5 | 40 |
| *Regional mean* | | *38.9* | *94* |
| West Nile | Arua | 8.8 | 34 |
| | Nebbi | 12.2 | 41 |
| | Zombo | 12.8 | 39 |
| *Regional mean* | | *11.3* | *114* |
| Overall mean | | 23.0 | 325 |

ajfand SCHOLARLY, PEER REVIEWED AFRICAN JOURNAL OF FOOD, AGRICULTURE, NUTRITION AND DEVELOPMENT Volume 19 No. 4 November 2019 PUBLISHED BY AFRICAN SCHOLARLY SCIENCE COMMUNICATIONS TRUST ISSN 1684 5374

**Table 2: Percentage of farmers using the various types of pesticides in the Arabica coffee growing regions of Uganda**

| Trade name | Active ingredient | Chemical group | WHO class* | Status ** | Mt Elgon (N=22) | Southern (N=43) | West Nile (N=13) | Grand mean |
|---|---|---|---|---|---|---|---|---|
| *Insecticides* | | | | | | | | |
| Cyperlacer, Dudu Cyper, Supacyeper, Umethrine | Cypermethrin 5% | Pyrethroid | II | In use | 13.6 | 18.6 | 7.7 | 15.4 |
| Ambush | Permethrin 50% EC | Pyrethroid | II | In use | 13.6 | 4.7 | 46.2 | 14.1 |
| Rocket 44 EC | Cypermethrin 4% + Profenofos 40% | Pyrethroid | II | In use | 13.6 | 11.6 | 7.7 | 11.5 |
| Tafgor 40 EC, Dudu Ethoate | Dimethoate 40% | Organophosphate | II | In use | 4.5 | 16.3 | 7.7 | 11.5 |
| Ascoris 48EC, Pyrinex 480 EC | Chlorpyrifos 480g/L | Organophosphate | II | In use | 18.2 | 4.7 | 0.0 | 7.7 |
| Stryker | Pyrethrins 6%, Piperonyl 60% Butoxide PBO | Pyrethroid | II | In use | 0.0 | 11.6 | 0.0 | 6.4 |
| Malathion | Malathion | Organophosphate | II | In use | 0.0 | 11.6 | 0.0 | 6.4 |
| Sumithion, Fenitrothion | Fenitrothion | Organophosphate | II | Banned | 4.5 | 7.0 | 0.0 | 5.1 |
| Unknown | - | - | - | - | 0.0 | 7.0 | 7.7 | 5.1 |
| Dudu Accelamectin | Abamectin and acelamiprin | Avermectins | Ib | In use | 4.5 | 2.3 | 0.0 | 2.6 |
| Imaxi, Konfidor | Imidacloprid | Neonicotinoid | II | In use | 0.0 | 4.7 | 0.0 | 2.6 |
| Dudu Alpha | Alpha-cypermethrin 3% | Pyrethroid | II | In use | 4.5 | 0.0 | 0.0 | 1.3 |
| Furadan 5 | Carbofuran | Carbamate | Ib | Banned | 0.0 | 2.3 | 0.0 | 1.3 |
| Lava 100% EC | Dichlorvos 100% | Organophosphate | Ib | Banned | 0.0 | 2.3 | 0.0 | 1.3 |
| Concoctions | - | - | - | - | 0.0 | 0.0 | 7.7 | 1.3 |
| *Fungicides* | | | | | | | | |
| Dithane M45 | Mancozeb 80% | Dithiocarbamate | U | In use | 4.5 | 2.3 | 30.8 | 7.7 |
| Cobox, Copper oxychloride | Copper oxychloride 50% | Inorganic Copper | II | In use | 4.5 | 4.7 | 7.7 | 5.1 |
| Microcop | Tribasic copper sulfate | Inorganic Copper | II | In use | 4.5 | 0.0 | 0.0 | 1.3 |
| Master | Mancozeb 64% +Metalaxyl 8% | Dithiocarbamate | U | In use | 4.5 | 0.0 | 0.0 | 1.3 |
| Orius | Tebuconazole | Triazole | II | In use | 0.0 | 2.3 | 0.0 | 1.3 |
| *Herbicides* | | | | | | | | |
| Mamba, Roundup | Glyphosate 360g/l | Phosphonomethyl | III | In use | 0.0 | 27.9 | 0.0 | 15.4 |
| Weedmaster, Green fire | Glyphosate 500g/l | Phosphonomethyl | III | In use | 0.0 | 18.6 | 0.0 | 10.3 |
| Weedex | Glyphosate 480g/l | Phosphonomethyl | III | In use | 0.0 | 7.0 | 0.0 | 3.8 |
| Gramoxone | Paraquat | Bipyridylium | II | Banned | 0.0 | 7.0 | 0.0 | 3.8 |

*Ib=Highly hazardous, II=moderately hazardous, III=slightly hazardous, U=unlikely to present acute hazard in normal use [11]; **Status [7]

## REFERENCES


1. **UCDA.** Uganda Development Authority/Minister of Agriculture, Animal Industry and Fisheries. UCDA monthly report for April 2016. http://ugandacoffee.go.ug/ download/2009/ April-2016.pdf. Last accessed on September 28, 2016. 2016.

2. **Hill RV** Risk, production and poverty: A study of coffee in Uganda. D. Phil thesis, University of Oxford. 2005.

3. **Musoli PC, Hakiza GJ, Birinkunzira JB, Kibirige-Sebunya I and P Kucel** Coffee (*Coffea* spp). **In**: Mukiibi JK (Eds.), Agriculture in Uganda Vol. II. Fountain Publishers/CTA/NARO. pp. 376-436. 2001.

4. **Nyambo BT, Masaba DM and GJ Hakiza** Integrated pest management of coffee for smallscale farmers in East Africa: Needs and limitations. *Int. J. Pest Manag.* 1996; 9 pp.

5. **Karungi J, Kyamanywa S, Adipala E and JM Erbaugh** Pesticide utilization, regulation and future prospects in small scale horticultural crop production systems in a developing country. **In**: Stoytcheva M (Ed.), Pesticides in the modern world – pesticides use and management, Chapter 2, 17 pp. 2011.

6. **Liebig T, Jassogne L, Rahn E, Laderach P, Poehling HM, Kucel P, van Hasten P and J Avelino** Towards a collaborative Research: A case study on linking science to farmers' perceptions and knowledge on Arabica coffee pests and diseases and its management. *PLoS One* 2016; **11(8)**: e0159392

7. **Otut A** Obsolete and banned pesticides. Ministry of Agriculture, Animal Industry and Fisheries (MAAIF), Uganda. 2017.

8. **Oesterlund AH, Thomsen JF, Sekimpi DK, Maziina J, Racheal A and E Jørs** Pesticide knowledge, practice and attitude and how it affects the health of small-scale farmers in Uganda: a cross-sectional study. *Afr. Health Sci.* 2014; **14(2)**.

9. **Okonya JS and J Kroschel** A cross-sectional study of Pesticide use and knowledge of Smallholder potato farmers in Uganda. *Biomed Res Int.* 2015; **9** pages.

10. **Gesesew HA, Woldemichael K, Massa D and L Mwanri** Farmers' knowledge, attitudes, practices and health problems associated with pesticide use in rural irrigation Villages, Southwest Ethiopia. *PLoS One* 2016; **11(9)**: e0162527.

11. **FAO/WHO.** Amount of poor-quality pesticides sold in developing countries alarmingly high. FAO/WHO press release, 1 February 2001. 2001.

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

13. **Kagezi GH, Kucel P, Egonyu PJ, Nakibuule L, Kobusinge J, Ahumuza G, Matovu RJ, Nakendo S, Luzinda H, Musoli CP, Kangire A and BF Chesang** Impact and farmers' coping mechanisms of the Black Coffee twig borer, *Xylosandrus compactus* (Eichhoff) (Coleoptera: Curculionidae) in Uganda. *Afr Crop Sci.* 2013; **11**: 285-292.

14. **Kwesiga J, Ekere W, Ochwo-Ssemakula MKN and J Karungi** Socio-economic factors affecting the utilization of integrated pest management strategies in hot pepper production in Uganda. 3rd Annual Makerere Research and Innovations Dissemination Conference, 11-12 April 2011, Kampala, Uganda. 2011.

15. **Lekei EE, Ngowi AV and L London** Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. *BMC Public Health* 2014; **14**: 319.

16. **Ngowi AVF, Mbise TJ, Ijani ASM, London L and OC Ajayi** Pesticides use by smallholder farmers in vegetable production in Northern Tanzania. *Crop Prot.* 2007; **26**: 1617–1624.

17. **Tandi TE, Wook CJ, Shendeh TT, Eko EA and CO Afoh** Small-scale tomato cultivators' perception on pesticides usage and practices in Buea Cameroon. *Health* 2014; **6**: 2945-2958.

18. **Amoako PK, Kumah P and F Appiah** Pesticides usage in cabbage (*Brassica oleracea*) cultivation in the Ejisu-Juaben municipality of the Ashanti region of Ghana. *Int. J. Res. Chem. Environ.* 2012; **2**: 26-31.

19. **IPM CRSP** Annual Report. Office of International Research and Development Integrated Pest Management Collaborative Research Support Program (IPM CRSP), Virginia Tech, Blacksburg, USA. 2007.

20. **Kaye E, Nyombi A, Mutambuze IL and R Muwesa** Mancozeb residue on tomatoes in Central Uganda. *J. Health Pollut.* 2015; **8**: 1–6.

21. **Tusiime SM** Evaluating horticultural practices for sustainable tomato production in Kamuli, Uganda. MSc Thesis, University of Iowa, Amos, Iowa. 2014.

22. **Mattah MM, Mattah PAD and G Futagbi** Pesticide application among farmers in the catchment of Ashaiman irrigation scheme of Ghana: Health implications. *J. Environ. Public Health* 2015; **2015**: 547272.

23. **Ashour M, Billings, L, Gilligan D, Hoel JB and N Karachiwalla** Do beliefs about agriculture inputs counterfeiting correspond with actual rates of counterfeiting? Evidence from Uganda. IFPRI Discussion Paper 1552. Washington, DC: International Food Policy Research Institute (IFPRI). 2016.