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Pesticides Use and Misuse in Cabbage *Brassica oleracea* var. *capitata* L. (Cruciferae) Production in Ghana: The Influence of Farmer Education and Training

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Authors' contributions

This work was carried out in collaboration between all authors. Authors BWA, KPA and OPA designed the study, wrote the protocol and wrote the first draft of the manuscript. All authors managed the literature searches, analyses of the study performed the structural equation modelling and discuss the conclusion. All authors read and approved the final manuscript.

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ABSTRACT

Global pesticides use is increasing with environmental contamination and consumer concerns over food safety reflecting this trend. A random sampling technique using a structured questionnaire was used to select 108 cabbage farmers in Ghana and were personally interviewed. The study found that most farmers had no formal education or were educated only to primary level so had limited capacity to read and understand labels of pesticides. Whilst biopesticides were popular, about 45% of the growers use synthetic insecticides in controlling pests such as diamondback moth, cabbage aphids, cabbage white butterfly, cabbage web worm and whitefly. Forty-four percent of growers do not adhere to use of the recommended rates of insecticides, because they fail to control pests effectively. Growers with formal education were more likely to adhere to the recommended application rates of pesticides. Respondents with training in agriculture, as opposed to formal education, tended not to adhere to recommended application rates. Overall, seventy-seven percent of growers did not wear any personal protective gear during chemical application and 39% had experienced at least a symptom of pesticide poisoning. Over 75% of respondents dispose of empty pesticides containers on the farm and 11% harvest their cabbage within one week after application of insecticides. Results suggest significant risks to farmers, consumers and the environment. It is expected that persistent education on the safe use of pesticides will lead to positive change in attitude of farmers.

Keywords: Pesticides; poisoning; education; training; personal protective gear.

1. INTRODUCTION

Threat to vegetable production by several species of insects has made the application of insecticides a compelling routine if high and quality vegetable produce is desired. Insecticides, and generally, pesticides are, however, with many problems. They are linked to human and animal health problems and negative environmental impacts [1-5]. Natural pest control for instance, is an important ecosystem service in agriculture that is supported by diverse taxa [6] but its effectiveness continuous to decline due to the application of harmful pesticides and loss of non-cropped habitats and landscape heterogeneity.

Pesticides are poisons by design and unsafe use of these chemicals is the most frequent cause of poisoning to agricultural workers especially in developing countries [7]. A major contributing factor to the high incidence of pesticides poisoning is the fact that, in several parts of the developing world, farmers continue to use highly persistent, banned insecticides such as DDT and lindane to control insects even in vegetable crops [8]. Other unhealthful practices such as application of pesticides in excess of recommended rates, tongue-testing of diluted pesticides to determine their potency and use of empty pesticides containers for storing drinking water occur in many developing countries [9]. Approximately three million agricultural workers in the world reportedly experience pesticide poisoning each year [10] and about 20,000 deaths are directly linked to agrochemical use of which 99% are from low and middle income countries [10,11].

In countries where data are available, pesticides poisoning presents a disturbing situation. For instance, in South Korea, the number of pesticide poisoning deaths between 1996 and 2005 was 25,360, which accounted for 58.3% of total poisoning fatalities [12]. A total of 140 deaths as a result of agricultural and horticultural pesticides poisoning occurred within a four-year period in Jordan [13]. In the early 2000s, an estimate of 400,000t of pesticides was used by Japanese farmers and about 1,000 deaths per year were associated with the use of that quantity of pesticides [14]. Out of desperation, and the desire to eliminate all insect pests so as to produce vegetables with no visible signs of insect damage, growers in many developing nations often spray high doses of poisonous chemical insecticides on their vegetable crops every week [15,16]. Often, some of the chemicals are meant for perennial plantation crops such as cocoa and coffee [15,16]. For instance, due to misuse and mishandling of insecticides, chemical residues in water, sediments and human body fluids such as blood and breast milk have been found in areas of intensive vegetable production in Ghana [8].

With people becoming conscious of their health, consumption of fresh vegetables such as cabbage, lettuce, tomatoes and garden eggs in Ghana has reduced due to the perceived misuse

of pesticide by vegetable growers [8,17]. Many households in Ghana for instance, have ceased consuming cabbage or will only purchase cabbage heads that have signs of insect damage; an indication that they were not frequently sprayed with high doses of harmful insecticides. Interestingly, the use of insect damage signs on cabbage heads as quality assurance indicator has gained grounds in other parts of the developing world including Sierra Leone (Abdulai Bangura, 2014. Personal comm.) Myanmar and Vietnam (Ye Lin Oo, 2015. Personal comm.).

For effective education on safe use of pesticides, it is important to know the current status of pesticides use among users. This study aimed at getting accurate knowledge about misuse of pesticides among vegetable growers using the cabbage production system as the test case. Often, this vegetable crop receives a lot of insecticide sprayings due to the difficulty in managing the numerous, and often obstinate pests including the diamondback moth and cabbage aphids that attack the crop.

2. MATERIALS AND METHODS

The study was conducted in the Kumasi metropolitan area of the Ashanti Region, Ghana (6°43'N 1°36'W; 287 m asl) during the first half of 2014. The metropolitan area is 254 km^2 with a population of 2,035,000 [18]. A random sampling technique was used to select 108 cabbage farmers. Cabbage farmers in the cabbage growing communities within the metropolitan area including Gyinyase, Boadi, Ayeduase, Kwame Nkrumah University of Science and Technology, Adwoato, Kwadaso Agric College, University of Education, Winneba (Kumasi campus) were identified and appropriate samples were selected. Personal interviews were conducted using a structured questionnaire. The questionnaire was explained to respondents and the freely participated in the study without being coerced. Respondents were free to exit the interview at any point in time if they had any reason to do so. This method enabled us to verify farmers' responses to the questions through observations. Data were analyzed using Statistical Package for Social Sciences [19], IBM Version 19.

3. RESULTS

Farmers involved in the survey were 88.9% males and 11.1% females. All female respondents were between the ages of 18 and 40 and they constituted 20% within that age group. Thus, cabbage production in the Kumasi Metropolitan area is male dominated. Majority of the farmers (56%) were between 18 and 40 years in age. Almost 78% of respondents had completed primary education whilst no respondents had a tertiary education. The percentage of respondents with no formal education and those who had completed secondary school was equal (11.1%). All female respondents completed primary education. Cabbage production in the Kumasi metropolis is on small scale basis. About 78% of respondents cultivate one acre or less and all respondents grow the *Oxylus* variety. Only 37% of respondents had received any form of training in agriculture and vegetable production.

No till land preparation with herbicides constitute the greater percentage with 67% of respondents using that system. With pest insect management, 44% of respondents use synthetic insecticides whilst the remaining 56% reported to rely on Bypel®. Synthetic insecticides used by the farmers include Attack® (Emamectin benzoate), Golan® (Acetamiprid), Lambda super® (Lambda cyhalothrin) and Mectin® (Avermectin). About 44.4% of the farmers do not use the recommended rate of insecticides. Respondents who had formal education were more likely to adhere to the recommended application rate of insecticides than were those with no formal education (χ^2 (2, N=108) =12.343, p=0.002<0.05). Some of the farmers had received training in vegetable production and the use of agro-chemicals but this did not significantly correspond with the correct vegetable production principles (χ^2 (1, N=108) =1.43, p=0.231>0.05). It appears that majority of respondents who had training in vegetable production and use of agro-chemicals do not adhere to the recommended application rates of insecticides. The majority of these farmers, representing about 55% percent, cited ineffectiveness of the recommended application rate as their reason.

Fig. 1 seeks to compare the effect of farmers' formal educational level and their training in vegetable production and use of agro-chemicals on adherence to the recommended application rates of pesticides. Generally, farmers' formal education level and adherence to recommended application rates of pesticides are positively related. This means that as the level of formal education increase, their adherence to the recommended rates of pesticides increase.

On disposal of empty pesticides containers, 77% of respondents throw them on the farm. Here, farmers with training in vegetable production and the use of agro-chemicals were more likely to burn or bury empty pesticides containers (35%) compared to those with no training (14.7%). The results show that training can lead to a significant change in attitude towards some practices (χ^2 (2, *N*=108) =6.22, p=0.045<0.05) even though the overall percentage is still low. The use of personal protective gear (PPG) was low among respondents (33.3%) (Fig. 2). As above, training in vegetable production and the use of agro-chemicals does make a slight difference, as 40% of such farmers use PPG compared to only 29.4% for those without the training. The relationship between use of PPG and training in vegetable production and the use of agro-chemicals was, however, not significant, (χ^2 (1, *N*=108) =0.64, p=0.425>0.05).

Withholding periods between spray application and harvesting were more likely to be observed with only 11% of respondents harvesting cabbage within one week of insecticide application. The relationship between training in vegetable production and use of agro-chemicals and the period between the last spray and harvesting was significant, (χ^2 (1, *N*=108) =3.97, p=0.046) as none of the trained farmers harvested cabbage within a week of spraying insecticide. A good percentage of respondents (39%) had experienced pesticide poisoning at least once in their lifetime. The farmers' pesticide poisoning experience was not dependent of their training status (χ^2 (1, *N*=108) =0.202, p=0.653>0.05). That is, farmers who had training in the use of pesticides did not differ from those who did not have when it comes to poisoning experience (Fig. 3).

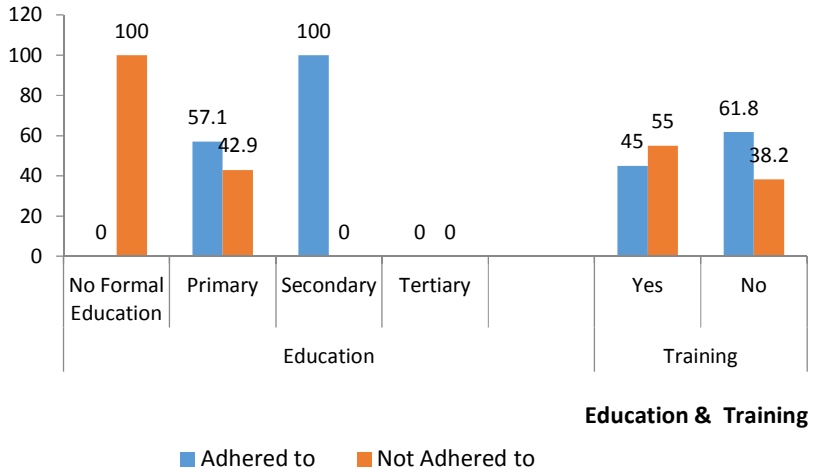

Fig. 1. Farmers formal education and agricultural training and adherence to the recommended rate pesticides

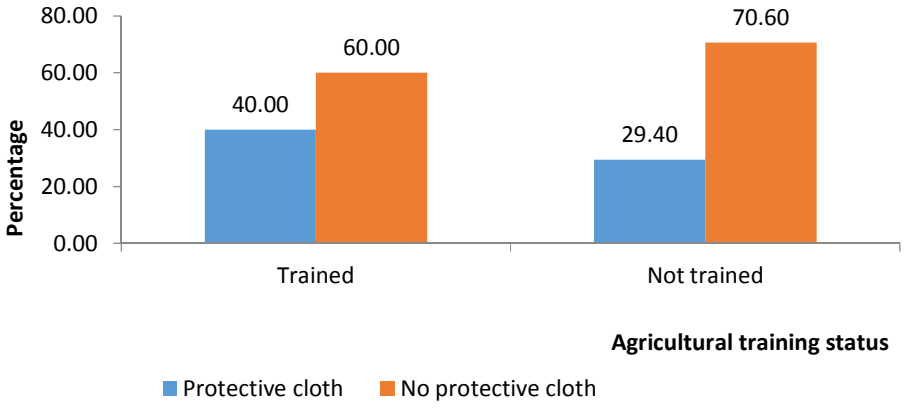

Fig. 2. Wearing of personal protective gear by cabbage growers in Kumasi, Ghana

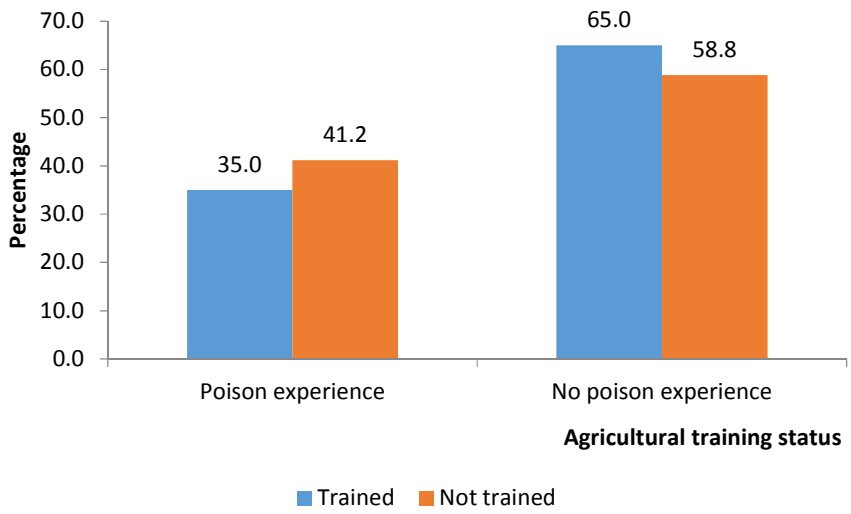

Fig. 3. Poisoning experience of cabbage farmers in the Kumasi metropolitan area of Ghana

4. DISCUSSION

Cabbage production in Ghana is dominated by people with low level of formal education. This study showed that 78% of cabbage growers had only primary education. The implication is that most of such growers would not be able read and understand any instructions written in English which is the official language [8]. In some countries a good percentage of cabbage growers have attained high formal education, and this might enhance their understanding of the procedures in using pesticides. For instance, [20] reported that at the Gaza, 13.2% cabbage growers had university degree whilst 42.9% had completed secondary school with only 13.2% and 8.5% being primary school leavers and illiterates respectively. The low level of education observed in this study implies that most of the farmers would not be able to read and understand pesticides labels as it is usually written in English language. According to [7], high incidence of pesticides poisoning is as a result of farmers' inability to understand and adhere to safety regulations in handling and application of pesticides as well as their indifferent attitudes towards personal safety. In the developing countries where acute pesticide poisoning frequently occurs, most of the farmers are illiterates or at best read only their local languages whilst pesticides are labelled in foreign, but official languages such as English and French [21]. This situation may deepen the woes of illiterate farmers and further expose them to more hazards associated with pesticides. In countries where high levels of illiteracy exist among farmers (who mostly handle pesticides), it might be helpful if authorities would persuade agrochemical manufacturers and suppliers to translate pesticide labels into the major local languages. These local language labels could be provided to farmers (based on their preferred local language) as complementary information sheet.

The choice of cabbage variety for cultivation in the study area was the *Oxylus.* Interestingly, all respondents in the present study grow that variety. Earlier study at the same area by [22] reported that 88% of cabbage farmers cultivate the *Oxylus* variety. Farmers prefer growing the *Oxylus* variety because of its compact head. However, this variety is susceptible to pests and diseases in the field (K.O. Fening, 2014. Personal comm.). The use of this single variety presents a worrying development because the industry could be in crisis if a more virulent pathogen emerges. Apparently, farmers had knowledge about other varieties and appreciated the risk in cultivating a single variety, but they expressed their reluctance in growing other varieties because *Oxylus* is the variety of choice by the consumers.

The use of PPG such as hat, hand gloves, face mask, respirators, goggles, boots and overall coat during pesticide application can reduce pesticide contamination to a level that might not present significant health hazard [23]. However, 77% of cabbage growers in the current study do not wear a complete PPG during pesticide application, even though they knew about the

importance of PPG in preventing pesticides contamination and possible poisoning. Surprisingly, during our farm survey one farmer was spotted spraying insecticide and wearing only short pants and without any footwear. In addition to financial constraints, farmers in the current study mentioned discomfort as the reason for their poor interest in PPG. A study at the Accra plains of Ghana by [23] revealed that 66% of farmers refused to wear PPG due to discomfort whilst the remaining percentage complained of financial constraints. The trend in Ghana collaborates with findings from other parts of the developing world. In Côte d'Ivoire for instance, about 53% of farmers do not wear PPG when applying pesticides [24] whilst [25] reported that in Nepal most of the farmers wear only shirts and pants during pesticides application and do not care about washing them before reuse. Farmers are thus prone to chemical contamination and possible poisoning. It was realized from this study that most of the farmers apply pesticides during hot afternoons, hence, feel uncomfortable wearing PPG. It must be stated that, in addition to the discomfort associated with spraying pesticides in hot afternoons, effectiveness of pesticides is reduced when applied during hot hours of the day due to volatilization of the chemicals. Even though farmers' claim to be aware of the hazards of pesticides, it appears they do not have complete knowledge about the long term health effects of being contaminated with the chemicals they work with. Farmer education regarding time of pesticide application is therefore important to reduce the risk of poisoning associated with not using PPG.

Pesticide poisoning signs vary and 39% respondents in this study reported of having once experienced symptoms such as skin irritation, nausea, headache, general weakness, dizziness and vomiting after pesticide application. Even though farmers generally know about pesticides toxicity, it appears they give much attention to oral toxicity or ingestion than other avenues such as dermal toxicity and inhalation. Expectedly, farmers' attitude towards exposure to pesticides is similar across the developing world. [26] reported on a study in Tanzania where 93% of respondents had once experienced pesticide-related poisoning in their lifetime. While studying to evaluate farmers' knowledge and attitude to pesticides in Ethiopia, [27] concluded that in addition to the provision of PPG, personal safety education and attitudinal change is imperative if farmers would reduce contact with pesticides.

Indiscriminate disposal of empty pesticides containers has serious environmental implications. Unfortunately, a huge percentage (77%) of cabbage growers in the current study throw away empty pesticides containers on the farm. This practice can potentially lead to contamination of streams and underground water which may be the source of drinking water for other people [8,24]. [8] had earlier reported of the presence of traces of pesticides in water, sediments and even human body fluids in areas of intensive vegetable production in Ghana of which the current study area forms part. Elsewhere in Africa, including Côte d'Ivoire and Nigeria, throwing away of empty pesticides containers on the farm is a frequent but a worrying development [24,28,29]. Due to its high water requirement, vegetable production in Ghana for instance often occurs close to perennial sources of water and thus indiscriminate disposal of pesticide containers could contaminate streams cause damage to aquatic life with potential consequences on human health. Pesticides residues from empty containers may also leak into soil and be absorbed and accumulate in plants. Traces of pesticides in soil may also have lethal effect on soil macro and micro fauna.

Insect pests of cabbage that farmers often encounter at the study area include diamondback moth (DBM), *Plutella xylostella* L. (Lepidoptera: Plutellidae), cabbage white butterfly *Pieris rapae* L. (Lepidoptera: Pieridae), cabbage aphids *Brevicoryne brassicae* L. (Hemiptera: Aphididae), whitefly *Bemisia tabaci* (Genn.) (Homoptera: Aleyrodidae) and web worm *Hellula undalis* Guenée (Lepidoptera: Pyralidae). It was, however, observed during the field survey that the predominant pestiferous insects were the DBM and cabbage aphids. Earlier studies had reported that the two herbivores are the most important pests of cabbage in Ghana [30]. Up to 44% of growers in this study use synthetic insecticides to manage these pests and 68.5% of the respondents apply insecticides once every week whilst 25.9% apply at a biweekly interval. The frequent applications of insecticides were, however, not enough to achieve absolute pest control as some fields were observed to be heavily infested, particularly with aphids. Reasons such as using insecticides below the recommended rate due to farmers' inability to read and understand pesticide labels or development of resistance to some insecticides might be responsible for the poor pest control. [31] had reported about poor control of cabbage

aphids with lambda-cyhalothrin at the study area. [32] reported that in Brazil cabbage growers could apply more than 20 insecticide sprays in a growing season without effective control due to insects resistance to insecticides.

Due to farmers' inability to monitor pests and control them at the most appropriate time, most of the respondents in this study used the calendar spray regime (spraying at scheduled periods with no regards to pest status) to manage pests and thus, they may apply insecticides whilst insects may not be present at levels that warrant control. Beside the contamination of the environment with high levels of insecticides, this system of pest management may be uneconomical because farmers may use more chemicals than required and thus, cost of production may unnecessarily be increased and that will reduce net profit.

Whilst 88.9% of the respondents leave more than one week between the last spray and harvest, 11.1% harvest according to market demand and do not show any regard to date of last spray and harvest. The attitude by the 11.1% of respondents could lead to the supply of cabbage with traces of pesticides due to the fact that some insecticides do not break down quickly. Often this results in ban of such vegetables to destinations e.g. the EU market where mechanisms are in place to detect pesticide residues in food commodities. Earlier study by [33] in Ghana had found contamination of vegetables with chlopyrifos, lindane (a product that was banned years ago) and endosulfan beyond the acceptable limit by the World Health Organization (WHO). Farmers who reported not to use synthetic insecticides in this study rely on Bypel® to manage pest insects. Bypel® is a brand of *Bacillus thuringiensis* formulated to control *P. rapae* and other Lepidopteran but will not be able to control pests such as cabbage aphids. Thus, Bypel® should be used alongside other insecticides to achieve total pests control.

Overall, the study has revealed that farmers pay less attention to pesticide safety, and this is particularly true in the developing countries. Unsurprisingly, nearly 75% of all deaths associated with pesticides poisoning occur in the developing world, even though they use only 15% of the global pesticide supply [10,34,35]. Also, food commodities in some developing nations contain pesticides beyond the maximum residue limit [34]. Whilst farmers will make every effort to protect their vegetables from insect pests damage, education on safe handling and use of pesticides must be encouraged. Besides, every pesticide that is sold in each country must be labeled in a language that can be read and understood by the indigenous farmers who form majority people who use pesticides. Perhaps, translation of the safety procedures on pesticides labels from the national languages into major local languages on a separate leaflet may be beneficial to local farmers. In addition, education and regular monitoring of farmers' activities by authorities may go a long way to safeguard the ecosystem and ensure sustainability.

5. CONCLUSION

In conclusion, the current study has shown that cabbage farmers in the Kumasi metropolis do not strictly adhere to the ideal pest management and pesticides application procedures. This may not be peculiar to the current study area but several places especially in the developing world. To minimize pesticide poisoning and boot up consumer confidence in eating cabbage and other vegetables, farmers must be educated on the safe use of pesticides. Formal education seemed to be more strongly associated with good practice than was training. Training, however, had a positive effect on some aspects of use such as container disposal but not other aspects. Whilst the high level of use of *Bt* sprays is good from a safety perspective, non-lepidopteran pests would not be controlled and, unless rotated with other insecticide types, will lead to resistance in pest population. Again, the use of a single cabbage variety revealed in the current study suggests a fragile system that could be devastated by an outbreak of a virulent pathogen strain or pest. It is recommended that persistent education on the safe use of pesticides should be encouraged among users of agrochemicals as this may lead to positive change farmers' attitude.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Devanand P, Rani PU. Biological potency of certain plant extracts in management of two lepidopteran pests of *Ricinus communis* L. Journal of Biopesticides. 2008;1(2):170-176.

2. Macharia I, Löhr B, De Groote H. Assessing the potential impact of biological control of *Plutella xylostella* (diamondback moth) in cabbage production in Kenya. Crop Protection. 2005;24(11):981-989.
3. Rathi J, Gopalakrishnan S. Insecticidal activity of aerial parts of *Synedrella nodiflora* Gaertn (Compositae) on *Spodoptera litura* (Fab.). Journal of Central European Agriculture. 2006;6(3).
4. Upasani SM, et al. Partial characterization and insecticidal properties of *Ricinus communis* L foliage flavonoids. Pest Management Science. 2003;59(12):1349-1354.
5. Weinberger K, Srinivasan R. Farmers' management of cabbage and cauliflower pests in India and their approaches to crop protection. Journal of Asia-Pacific Entomology. 2009;12(4):253-259.
6. Balzan MV, Bocci G, Moonen AC. Landscape complexity and field margin vegetation diversity enhance natural enemies and reduce herbivory by Lepidoptera pests on tomato crop. BioControl. 2016;61(2):141-154.
7. Forget G. Pesticides and the third world. Journal of Toxicology and Environmental Health, Part A Current Issues. 1991;32(1): 11-31.
8. Ntow WJ, et al. Farmer perceptions and pesticide use practices in vegetable production in Ghana. Pest Management Science. 2006;62(4):356-365.
9. Williamson S, Ball A, Pretty J. Trends in pesticide use and drivers for safer pest management in four African countries. Crop Protection. 2008;27(10):1327-1334.
10. Darko G, Akoto O. Dietary intake of organophosphorus pesticide residues through vegetables from Kumasi, Ghana. Food and Chemical Toxicology. 2008; 46(12):3703-3706.
11. Konradsen F. Acute pesticide poisoning–a global public health problem. Dan Med Bull. 2007;54(1):58-59.
12. Lee WJ, et al. Deaths from pesticide poisoning in South Korea: Trends over 10 years. International Archives of Occupational and Environmental Health. 2009;82(3):365-371.
13. Abdullat EM, et al. Agricultural and horticultural pesticides fatal poisoning; the Jordanian experience 1999–2002. Journal of Clinical Forensic Medicine. 2006;13(6): 304-307.
14. Kesavachandran C, et al. Health risks of employees working in pesticide retail shops: An exploratory study. Indian Journal of Occupational and Environmental Medicine. 2009;13(3):121.
15. Timbilla J, Nyarko K. A survey of cabbage production and constraints in Ghana. Ghana Journal of Agricultural Science. 2006;37(1):93-101.
16. Amoah P, et al. Irrigated urban vegetable production in Ghana: Microbiological contamination in farms and markets and associated consumer risk groups. Journal of Water and Health. 2007;5(3):455-466.
17. Armah FA. Assessment of pesticide residues in vegetables at the farm gate: Cabbage (*Brassica oleracea*) cultivation in Cape Coast, Ghana. Research Journal of Environmental Toxicology. 2011;5(8):180-202.
18. Owusu G, Agyei-Mensah S. A comparative study of ethnic residential segregation in Ghana's two largest cities, Accra and Kumasi. Population and Environment. 2011;32(4):332-352.
19. Nie NH, Bent DH, Hull CH. SPSS: Statistical package for the social sciences. McGraw-Hill New York; 1970.
20. Yassin M, Mourad TA, Safi J. Knowledge, attitude, practice and toxicity symptoms associated with pesticide use among farm workers in the Gaza Strip. Occupational and Environmental Medicine. 2002;59(6): 387-393.
21. Isman MB. Botanical insecticides: For richer, for poorer. Pest Management Science. 2008;64(1):8-11.
22. Osei M, et al. Practices and constraints to cabbage production in urban and peri-urban Ghana: Focus on Brong Ahafo and Ashanti regions. Basic Res J Agric Sci Rev. 2013;2(1):5-14.
23. Clarke E, et al. The problems associated with pesticide use by irrigation workers in Ghana. Occupational Medicine. 1997; 47(5):301-308.
24. Ajayi OC, Akinnifesi FK. Farmers understanding of pesticide safety labels and field spraying practices: A case study of cotton farmers in northern Cte dIvoire. Scientific Research and Essays. 2007; 2(6):204-210.
25. Atreya K. Pesticide use knowledge and practices: A gender differences in Nepal. Environmental Research. 2007;104(2): 305-311.

26. Lekei EE, Ngowi AV, London L. Farmers' knowledge, practices and injuries associated with pesticide exposure in rural farming villages in Tanzania. BMC Public Health. 2014;14(1):1.
27. Mekonnen Y, Agonafir T. Pesticide sprayers' knowledge, attitude and practice of pesticide use on agricultural farms of Ethiopia. Occupational Medicine. 2002; 52(6):311-315.
28. Oluwole O, Cheke RA. Health and environmental impacts of pesticide use practices: A case study of farmers in Ekiti State, Nigeria. International Journal of Agricultural Sustainability. 2009;7(3):153-163.
29. Sosan MB, Akingbohungbe AE. Occupational insecticide exposure and perception of safety measures among cacao farmers in Southwestern Nigeria. Archives of Environmental & Occupational Health. 2009;64(3):185-193.
30. Amoabeng BW, et al. Tri-trophic insecticidal effects of African plants against cabbage pests. PloS One. 2013;8(10): e78651.
31. Fening K, et al. Sustainable management of two key pests of cabbage, *Brassica oleracea* var. *capitata* L. (Brassicaceae), using homemade extracts from garlic and hot pepper. Organic Agriculture. 2013;3(3-4):163-173.
32. Oliveira ACD, et al. Resistance of Brazilian diamondback moth populations to insecticides. Scientia Agricola. 2011;68(2): 154-159.
33. Amoah P, et al. Pesticide and pathogen contamination of vegetables in Ghana's urban markets. Archives of Environmental Contamination and Toxicology. 2006; 50(1):1-6.
34. Koul O. Insect antifeedants. CRC Press; 2004.
35. Armah FA. Assessment of pesticide residues in vegetables at the farm gate: Cabbage (*Brassica oleracea*) cultivation in Cape Coast, Ghana. Research Journal of Environmental Toxicology. 2011;5(3):180.

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