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# High Levels of Some Insecticides on Cabbage Samples (Brassica Oleracea L. Var Capitata) From Rural and Urban Farms in Ghana

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***Abstract:*** *Pesticide residue levels in cabbage samples from Kwaebibirem District (KD) (rural area) and Accra Metropolitan Assembly (AMA) (urban area) may be an indicator of how pesticides were used by rural and urban vegetable farmers in Ghana. A survey was conducted to determine common pesticides used by farmers and the adherence to pre-harvest intervals. Cabbage samples were collected from three farmers in each District for residue analysis. The survey revealed that farmers in KD preferred using pyrethroids while those in AMA preferred organophosphates and pyrethroid. Majority of the farmers in KD (80%) and in AMA (60%) observed a pre-harvest interval of more than 5 days and 1 -2 days respectively. Pesticide residue analyses detected six different pesticides in the cabbage samples: three pyrethroids, two organophosphates and one organochlorine were detected on the samples. Residue levels in samples from KD were not more than the EU MRLs. Pesticide residue levels (mgkg$^{-1}$) of lambda-cyhalothrin (0.48 ± 0.19), cypermethrin (1.70 ± 1.37) and dimethoate (0.07 ± 0.05) in cabbage samples from AMA were more than EU MRLs. Pesticide residue levels of lambda-cyhalothrin, cypermethrin, and permethrin in cabbage samples in AMA were three folds, four folds and three folds higher than in samples from KD respectively. There was a strong correlation: r = 0.7473 for dimethoate + chlordane and r = 0.7771 for permethrin + chlordane indicating possible mixing or alternation of pesticide types during spraying. Residue levels beyond the EU MRLs in this study suggest the need to put into effect regulations and training necessary to optimize pesticide use. Further ramifications and implications for these findings are discussed in this paper.*

***Keywords:*** *pyrethroid, dimethoate, cabbage, EU MRL, AMA, KD*

## I. Introduction

Vegetable cultivation in Ghana contributes to the GDP and play a significant role in food security. In Ghana, a common vegetable grown among urban, peri-urban and rural vegetable farmers is cabbage [1]. However, the production of cabbage and other vegetables is impeded by numerous biotic and abiotic constraints; high cost of agrochemicals like fertilizers and pesticides, damage by pests and diseases, inadequate storage facilities are a few constraints [2]. Diamond back moth, DBM (*Plutella xylostella* L.), cabbage webworm (*Hellula undalis* F.), cabbage leaf looper (*Trichoplusia ni* Hbn.) and cabbage aphid (*Brevicoryne brassicae* L.) are the most serious pests of cabbage in Ghana [3]. DBM is the most serious pest of cabbage causing percentage leaf damage between 18 to 31% and in severe cases total crop failure [4].

In order to prevent loss of market value and some in cases total crop failure, farmers have resorted to the use of pesticides [5]. The improper use of these pesticides have been reported to cause toxicological and environmental problems; toxic residue in food and soil, water bodies and elimination of non-target organisms and development of resistant strains of pests have been reported in Ghana [6, 7, 8, 9]. The use of pesticide is considered indispensable in the near and distant feature [10]. This implies that farmers will continue to use these pesticides thereby increasing the chances of pesticide poisoning. Pesticide poisoning can be direct or indirect; direct poisoning can occur from contact or consumption of pesticides knowing or unknowing, indirect poisoning can result from consumption of food and drinks contaminated with high levels of pesticide residues.

While the need for fresh vegetable consumption is encouraged, consumers are also concerned about the possible pesticide residue on vegetables and the associated health implications. The health complications associated with misuse of pesticide can be benign or malignant. Benign effects include dizziness, drowsiness, eye and skin irritations. Malignant effects include infertility, paralysis and death [7]. High pesticide residue has been recorded on many vegetables in Ghana by different researchers [8, 9, 11, 12, 13].

This study sought to identify the types of pesticides used by small scale vegetable farmers and their levels in cabbage samples at harvest. The authors expected different levels of pesticide residues in the cabbage samples from rural and urban areas. Low educational standards, lack of adequate knowledge precludes rural farmers from appropriate use of pesticides [14]. As such we expected pesticide residue levels in cabbage samples from a rural area (Kwaebibirem District, KD) to be higher than those in an urban area (Accra Metropolitan Assembly, AMA).

## II. Methodology

### 2.1 Study areas

One urban and a rural district were selected for this study. Accra Metropolitan Assembly (AMA) (Urban District) in Greater Accra Region and Kwaebibirim District (Rural District) in the Eastern Region of GhanaAccra is the capital city of Ghana and is located between latitude 5$^{o}$32¹ and 5$^{o}$38¹ N and longitude 0$^{o}$06¹ and 0$^{o}$16¹ W on the South East coast of the country. The present Metropolitan area encompasses the city itself and the outlying semi urban Ga Districts [15]. Three communities known for the intense urban vegetable cultivation namely; Dzorwulu, Korle-Bu and Airport were selected.

Kwaebibirim District is in the Eastern Region of Ghana. It lies between 6$^{o}$ and 7$^{o}$ North and between longitude 1$^{0}$30¹ West and 0$^{o}$30¹ East. Sixty to seventy percent of the inhabitants are mainly engaged in agriculture. Crops like oil palm, cocoa, plantain, rubber and vegetables are predominantly grown in this district [15]. Three vegetable growing communities were selected from this District for the study; Topremang, Apinamang and Essienkyiem

### 2.2 Survey

The survey was conducted from August – November, 2012. Ten farmers were randomly interviewed from each community, making a total of sixty (60) farmers, 30 from AMA and 30 from Kwaebibirim district. A survey was conducted to obtain a baseline data on the type of pesticides used by the farmers in KD and AMA. KD is a rural area and AMA is an urban area. The farmers were also asked about the length of the pre-harvest time they observe.

### 2.3 Pesticide residue analysis

#### 2.3.1 Sample collection

Three farmers each from KD and AMA were randomly selected for this process. Two mature and marketable cabbage heads were randomly selected at harvest. Special codes were given to the samples based on the location from where they were collected: KA1, KA2 to AD1, and AD2; where the first letter 'K' and 'A' represent farmers from Kwaebibirem District and Accra Metropolitan Assembly, respectively. The second letter and number represent the neighbourhood from which the farmers come from and the numbers '1' and '2' represent the first and the second sample collected from the farmers.

Samples were collected into polythene bags and conveyed to Biochemistry Department, University of Ghana. In the laboratory, the cabbage heads were then sliced longitudinally into cone shape, chopped into pieces and 50g of each sample was weighted and transferred into the conical flask. N-hexane (100mL) was added and stored in the refrigerator at 10$^{o}$C until used for residue extraction.

#### 2.3.2 Extraction of pesticide residue

Samples were removed from the refrigerator and allowed for to thaw 30mins. N-hexane was the solvent used for the extraction. The thawed samples were homogenized using a blender. The liquid portion was decanted into 250mL conical flask. Twenty five mls of hexane was added to the homogenate and was further homogenized. The resultant homogenate was transferred into a falcon centrifuge tube (14mL) and centrifuge on a bench top centrifuge at 3000rpm (rotor radius = 11.5cm) for 3 minutes at room temperature. The supernatant was then decanted into 250mL corresponding conical flask.

In order to reduce bulk and water, which can interfere with clean-up 15g of anhydrous sodium sulphate ($Na_2SO_4$) was added to the sample, shaken vigorously for 1 minute and the solvent phase was then decanted into separate conical flask (250ml).

#### 2.3.3 Concentration of pesticide residues

The pooled extracts were poured into a round bottom flask and concentrated using the Rotary Vacuum Evapourator to dryness. The rotary vacuum flask was then rinsed twice, each time with 2mL of hexane and then transferred into a 10mL vial. The samples in each vial were later dried under nitrogen gas and re-dissolved in 5mL hexane. The concentrate was then subjected to solid phase extraction (SPE) using Altech Previal C18 solid phase extractor.

**2.3.4 Solid phase micro-extraction (SPME) of pesticide residue**

The method of extraction was primarily aimed to obtain very polar pesticides (e.g organophosphates) and less polar pesticides (e.g pyrethroids). Empty 5mL vial was weighed and aliquot of cabbage extract (1mL) was pippeted into the vials, the solvents were completely dried (evapourated) under nitrogen gas and then weighed and then dissolved in hexane to obtain1mg/µl of each sample.

The SPME was mounted on a clamp and stand and was pre-equilibrated by allowing 3ml of methanol to run through the tube till the solvent was about 1mm above the column packing. After pre-equilibration, the samples were applied to the SPE column. The insecticides were eluted with methanol (2mL), ethylacetate (2ml) and hexane (2ml) in that order. The effluent was collected as fractions into pre-weighed 2ml vials. The fractions obtained were dried under nitrogen gas and the weights of extracted residues were obtained. The residues were dissolved in hexane (1ml)

2.3.5 Identification and quantification of pesticide residue

The samples were analyzed at the Chemistry Department, Pesticide Residue Analysis laboratory of the Ghana Standard Authority (GSA) using CP3800 gas chromatography-mass spectrometry. The GC was fitted with an electron capture detector and analytical capillary column (30m + 10m EZ Guard, i.d 0.25mm, fused with silica coating VF-5ms, 0.25µm film). The injector temperature was 270$^oC$ and oven temperature was programmed as 90$^oC$ (1min), 30$^oC$/min till 240$^oC$ followed by 5$^oC$/min up to 300$^oC$ and finally 300$^oC$ for 3 min. The carrier gas was nitrogen maintained at a constant flow rate of 1ml/min. The identity of the residues was established by their retention time and masses/fragmentation patterns. Their levels were also determined by the GC-MS analysis.

2.4 Data analysis

Means computed for pesticide residue identifies were compared to the EU MRL for that pesticide. A correlation analysis was conducted for the various pesticide residues in order to examine possibilities of mixing pesticides or use of multiple pesticides during a growing season. All analysis was done with SPSS (ver. 16)

## III. Results

3.1 Socio-demographics of small scale vegetable farmers

The socio-demographic variables of 60 farmers from Kwaebibirem District (hereafter referred to as KD) and AMA are shown in Table 1. More women were involved in vegetable production in KD than in AMA ($p < 0.001$). More than 90% of all the farmers were married. No significant difference was observed in the level of education, but more farmers from AMA (33.33%) had attended tertiary education than those from KD (16.6%). There was a significant difference in the age of the farmers from KD and those from AMA. However, the age range of farmers from KD was wider than in AMA. Farming experience (in years) was significantly higher for farmers from AMA (13.43 ± 1.1) than KD (10.2 ± 1.7), ($p < 0.05$)

3.2 Types of pesticide used

Farmers used different pesticides groups to control pests and diseases on the vegetables. The pesticide groups include insecticides, herbicides and fungicides. Within each group of pesticide, a particular active ingredient was recorded in different trade names. Fungicides and herbicides were widely used by the vegetable farmers in these study areas (Table 2).

**Table 1: Socio-demographic variables of vegetable farmers in KD and AMA**

| **Variables** | **Kwaebibirem District** | | | **Accra Metropolitan Assembly** | | **0.05** |
|---|---|---|---|---|---|---|
| | **Frequency** | **Percentage (%)** | | **Frequency** | **Percentage (%)** | |
| **Gender** | | | | | | < 0.05 |
| Male | 26 | 86.7 | | 30 | 100 | $\chi^2$ =66.43 |
| Female | 4 | 13.3 | | 0 | 0.0 | |
| **Marital status** | | | | | | NS |
| Married | 29 | 96.67 | | 27 | 90.0 | $\chi^2$ =1.071 |
| Not married | 1 | 3.33 | | 3 | 10.0 | |
| **Education level** | | | | | | NS |
| None | 6 | 20.0 | | 2 | 6.67 | $\chi^2$=5.026 |
| Primary | 5 | 16.67 | | 8 | 26.67 | |
| Secondary | 14 | 46.67 | | 10 | 33.33 | |
| Tertiary | 5 | 16.67 | | 10 | 33.33 | |
| **Age (years)** | | | | | | |
| 20 - 30 | 1 | 3.33 | | 4 | 13.33 | |
| 31 - 40 | 7 | 23.33 | | 13 | 43.33 | |
| 41 - 50 | 16 | 53.33 | | 12 | 40.00 | |
| 51 - 60 | 4 | 13.3 | | 1 | 3.33 | |
| 60 ≥ | 2 | 6.66 | | 0 | 0.0 | |
| *Mean (± s.e) age 45.7 ± 1.7* | | | | *Mean (± s.e) age 39.30 ± 1.2* | | < 0.05 |

Significance for location difference ($\chi^2$ test for educational level, Fisher's exact test for gender status, marital status; *t* test for age), **NS** – Not significant (***P*** > **0.05)**

### 3.3 Pre-harvest interval

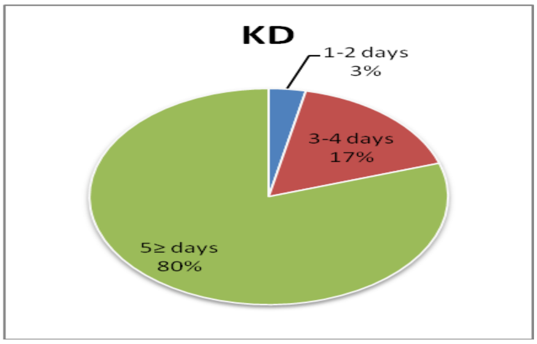
Pre-harvest interval is the time allowed to elapse after spraying a pesticide before harvesting is done. This time is allowed so that the pesticide in the plant gets enough time to degrade before harvesting and consumption. Analysis of the pre-harvest interval reveals that majority of the farmers in KD (80%) and AMA (60%) observed a pre-harvest interval of 5≥ days and 1 – 2 days respectively (Figure 1).

### 3.4 Pesticide residue detected on cabbage samples

A total of six pesticide residues were detected in the cabbage samples: three pyrethroids (lambda-cyhalothrin, cypermethrin and permethrin), two organophosphates (dimethoate and chlorpyrifos) and one organochlorine (chlordane) (Table 3). The correlation analysis reveals that there was a strong correlation: r = 0.7473 for dimethoate (organophosphate) + chlordane (organochlorine), r = 0.7771 for permethrin (pyrethroids) + chlordane (organochlorine) and r = 0.672 for permethrin (pyrethroid) + chlordane (organochlorine) (Table 4).

**Table 2. Types of pesticides used by farmers from KD and AMA**

| | **Trade names** | **Active Ingredient (AI)** | **# of farmers** | |
|---|---|---|---|---|
| | | | **KD** | **AMA** |
| **Insecticides** | Karate 5 EC | Lambda-cyhalothrim | 20 | 2 |
| | Lambda-M | Lambda-cyhalothrin (25g/L) | 3 | 0 |
| | Bossmate | Lambda-cyhalothrin (2.5%) | 6 | 0 |
| | PAWA 2.5 EC | Lambda-cyhalothrin (25G/L) | 3 | 5 |
| | Kilset 2.5 EC | Lambda-cyhalothrin 25g | 1 | 0 |
| | Kombat 2.5 EC | Lambda cyhalothrin | 7 | 0 |
| | Conquest | Lambda-cyhalothrin | 1 | 0 |
| | Terminex 48EC | Chlorpyrifos-ethyl (480g/L) | 1 | 0 |
| | Dursban 4E | Chlorpyrifos | 7 | 6 |
| | Sunpyrifos 48% EC | Chlorpyrifos-ethyl (480g/L) | 13 | 8 |
| | Cydim super | Cypermethrim (36g/L) + Dimethoate(400g/L) | 3 | 17 |
| | Confidor | Imidacloprid (200g/L) | 12 | 0 |
| | Super Agro Blaster | Pyrethrum (1%) | 2 | 0 |
| | Cocostar Extra 27 EC | Bifenthrin (27g/L) | 3 | 0 |
| | Anti-Attah (Akape) | Dimethoate | 2 | 18 |
| | Attack (EC) | Pirimiphos-methyl 475g/L Permethrin 25g/L | 3 | 25 |
| | Actellic 50 EC | Pirimiphos methyl (505 w/w) | 0 | 1 |
| | Thiopsin | Thiophanate methyl 70% | 8 | 0 |
| | Goland SL | Acetamiprid 200g/L | 1 | 1 |
| | Protect 1.9 EC | Emamectin Benzoate 1.92%EC | 0 | 3 |
| | Mectin | Avermectin 5g/L | 1 | 23 |
| **Fungicides** | Champion 80WP | Copper hydroxide (77%) | 8 | 0 |
| | Funguran-OH 50WP | Copper hydroxide (77%) | 2 | 0 |
| | Dithane M45 | Mancozeb (800g/kg) | 2 | 10 |
| | Gallon 2 | Triclopyr | 2 | 1 |
| | Conti-zeb "5" 80%WP | Mancozeb | 1 | 20 |
| | Victory 72 WP | Metaoxyl-8% Mancozeb 64% | 0 | 3 |
| | Trimaneb 80 WP | Maneb (800g/L) | 0 | 1 |
| **Herbicides** | Kocide WP | Copper hydroxide | 12 | 1 |
| | Atrazine 500 SC | Atrazine (500g/L) | 0 | 1 |
| | Pendicox 50EC | Pendimethalin (500g/L) | 0 | 1 |
| | Roundup | Glyphosate (360g/L) | 24 | 19 |
| | Paraquate | Paraquate | 6 | 2 |
| | Stomp 500EC | Pendimethalin (500g/L) | 2 | 4 |
| | Pendimax | Pendimethalin (200g/L) + Oxyfluorfen (140g/L) | 0 | 2 |



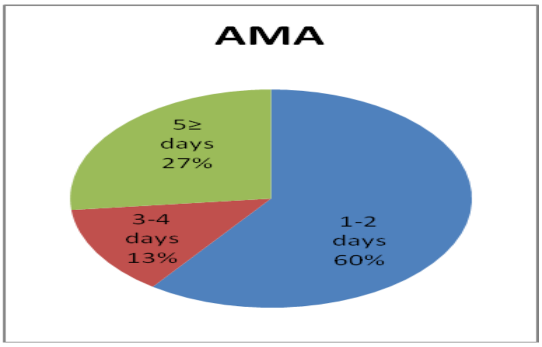




Figure 1. Length of pre-harvest interval observed by farmers

**Table 3. Pesticide residue levels (mg $kg^{-1}$) detected in cabbage samples collected from farmers in KD and AMA at harvest**

| | | | | KD | | | | AMA | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Pesticide class** | **Active ingredients** | **E.U MRLs** | **Year of adoption** | **Mean** | **s.d** | **Min** | **Max** | **Mean** | **s.d** | **Min** | **Max** |
| | Lambda-cyhalothrin | 0.3mg $kg^{-1}$ | 2009 | 0.11 | 0.06 | 0.015 | 0.376 | <u>**0.37***</u> | 0.20 | 0.016 | 0.738 |
| Pyrethroids | Cypermethrin | 0.7mg $kg^{-1}$ | 2009 | 0.25 | 0.05 | 0.125 | 0.424 | <u>**1.13***</u> | 0.86 | 0.012 | 4.534 |
| | Permethrin | 0.5mg $kg^{-1}$ | 2008 | 0.19 | 0.04 | 0.113 | 0.361 | 0.36 | 0.10 | 0.238 | 0.557 |
| | Chlorpyrifos | 1.0 µg $g^{-1}$ | 2003 | 0.31 | 0.10 | 0.205 | 0.417 | 0.40 | 0.15 | 0.024 | 1.070 |
| Organophosphate | Dimethoate | 0.05 µg $g^{-1}$ | 2003 | 0.01 | 0.002 | 0.006 | 0.010 | <u>**0.07***</u> | 0.05 | 0.018 | 0.123 |
| Organochlorine | Chordane | 0.0 µg $g^{-1}$ | 2003B | <u>**0.19**</u> | 0.04 | 0.111 | 0.354 | <u>**0.27**</u> | 0.16 | 0.104 | 0.427 |

Key

| **Notation** | **Meaning of symbols** |
|---|---|
| B | Banned for use on vegetables |
| * | Pesticide residue level exceed that of EU MRL |
| | |

**Table 4. Correlation matrix for pesticides residues found on cabbage samples from KD and AMA**

| | **Lambda-cyhalothrin** | **Cypermethrin** | **Permethrin** | **Chlorpirifos** | **Dimethoate** | **Chlordane** |
|---|---|---|---|---|---|---|
| **Lambda-cyhalothrin** | - | - | - | - | - | - |
| **Cypermethrin** | r = 0.2706 | - | - | - | - | - |
| **Permethrin** | r = 0.0448 | r = 0.0375 | - | - | - | - |
| **Chlorpirifos** | r = 0.0448 | r = 5 x $10^{-6}$ | r = 0.0038 | - | - | - |
| **Dimethoate** | r = 0.2177 | r = 0.0921 | r = 0.7771* | r = 0.1575 | - | - |
| **Chlordane** | r = 0.2331 | r = 0.4036 | r = 0.6727* | r = 0.0391 | r = 0.7473* | - |

** strong correlation, r – correlation coefficient*

## IV. Discussion

Vegetable farmers in KD were older in age than those in AMA. This suggests that the farmers in AMA were young men who left the rural area to the city for greener pastures and ended up in urban farming because they could not find any formal job. This could still be indigenous young men who are investing in the agriculture which has often been branded an activity for the old practiced in rural areas.

The level of education attained by both sets of farmers was almost the same with some attending tertiary education. This however contradicts the reports from other researchers [14, 15] that farmers in urban areas are more educated than those in rural areas. One reason why this may have changed may be due to the fact that some of the farmers (20%) in KD are pensioners from formal engagement with the government or other private companies who probably have had some education.

Farmers in AMA had stayed longer in farming than those in KD. This could be due to the fact that about 20% of the farmers from KD are pensioners who took up farming after active service in government employment whilst over 80% of the farmers in AMA are younger ones who had been in farming with their parents and eventually took over.

Among the insecticides, the pyrethroid lambda-cyhalothrin and the organophosphate chlorpyrifos were widely used by farmers from KD. Dimethoate, pirimiphos-methyl 475g/L permethrin 25g/L and avermectin 5g/L were widely used by vegetable farmers from AMA. This result reveals that there was a dichotomy in insecticide preference as most KD farmer preferred pyrethroids while most farmers from AMA preferred organophosphates. Limited land for cultivation by AMA farmers may have encouraged repeated farming on the same piece of land, thus more potent insecticides (organochlorine and organophosphates) was needed to control the insect pests which probably have shown some resistance. A similar research conducted by [8] revealed that vegetable farmers in Ghana used pyrethroids, organophosphates, carbamates and organochlorines for vegetable pest control.

More farmers in KD observed a lengthier pre-harvest interval than those in AMA. Farmers in AMA complained that there was no time for this due to pressure from the buyers. These buyers easily access these farmers, and thus could buy any day, anytime irrespective of the day and time the last pesticide regime was applied. This was not the case for the farmers in KD who have to wait and harvest only on market days because the buyers did not go around on daily basis. Pre-harvest interval or with-holding period is often specified on the pesticide labels. Most of the pesticide requires about seven or more days interval for vegetables. Harvesting vegetables earlier before the pre-harvest interval can cause direct increase in the amount of pesticide residue in the vegetables thus exposing consumers to pesticide residue.

This study reveals that cabbages sold in some Ghanaian local markets have pesticide residues above the recommended standards. This study is in line with many other published works in Ghana [8, 12, 14] reporting high pesticide residue levels than recommended on vegetables. Such findings imply that Ghanaian vegetable farmers cannot benefit from premium prices of vegetables in many foreign markets especially in Europe where emphasis is on quality control of pesticide residues in food stuffs.

Lambda-cyhalothrin, cypermethrin and dimethoate levels in cabbage samples from AMA exceeded the EU MRL while pesticides in the samples from KD were below the EU MRL. One possible reason for these high levels of pesticides in cabbage samples from AMA could be because they harvest the cabbages within the allocated pre-harvest intervals. Chlordane is an organochlorine banned for use on vegetables. Traced amounts of chlordane were detected on the cabbage samples, though none was more than 0.5µg the amount in samples from AMA was twice that of KD. These strong correlations observed in this study suggest that the farmers practice mixing of pesticides or alternating the pesticides as they spray in a growing season. These correlations also reveals that the mixing or alternation was common for pesticides of different classes suggesting that some of the insect pest were already showing signs of multiple resistance – when insects show resistance to pesticides of different classes.

## V. Conclusion

Pesticides (insecticides) play a fundamental role in cabbage cultivation in Ghana both for urban and rural cabbage growers. The farmers used pyrethroids, organophosphates and organochlorine for pest control in cabbage. Effective control of pesticide use is required as some of the pesticides used are banned for vegetable use. More training on overall use of pesticides is required equally for both urban and rural vegetable growers as this will intend limit over dependence on pesticides and will eventually reduce the pesticide residues in vegetables like cabbages given it is eaten raw in some case.

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## References

[1]. M. K. Osei., K. Osei., H. Braimah., M. B. Mochiah., J. N. Berchie., G. Bolfey-Arku., and J. N. L. Lamptey; Practices and constraints to cabbage production in urban and peri-urban Ghana: Focus on Brong Ahoa and Ashanti Regions. Basic Research Journal of Agricultural Science and Review. 2(1), 2011. 05 – 14

[2]. D. T. Achiri; Comparative studies of pesticides use patterns in small scale vegetable farms in rural and urban areas in Ghana. Master of Philosophy (MPhiL) in Entomology; University of Ghana; Accra – Ghana. 2013

[3]. M. A. Cobblah., K. Afreh-Nuamah., D. Wilson., and M. P. Osae: Parasitism of Plutella xylostella (L.) (Lepidoptera: Plutellidae) populations on cabbage Brassica oleracea var. capitata (L.) by Cotesi plutellae (Kurdjumov) (Hymenoptera: Braconidae) in Ghana. West African Journal of Applied Ecology. 20(1): 2012. 37 – 45

[4]. M. B. Mochiah., P. K. Baidoo., and M. Owusu-Akyaw: Influence of different nutrient applications on insect populations and damage of cabbage. Journal of Applied Biosciences. 38: 2011. 2564 - 257

[5]. J. Waceke: Plant parasitic nematodes associated with cabbages in Kenya. Proceedings of the 8th African Crop Science Society Conference, 27 – 31 October 2007, El-Minia, Egypt, pp. 1071 – 1074. 2007

[6]. B. Dinham: Growing vegetables in developing countries for local urban populations and export markets: problems confronting small-scale producers. Pesticide Management Science. 59: 2003. 591-596

[7]. W. J. Ntow., L. M. Tagoe., P. Drechsel., P. Kelderman., H. J. Gijzen., and E. Nyarko, E: Accumualtion of persistent organochlorine contaminants in milk and serum of farmers from Ghana. Environmental. Research., 106: 2008. 17–26.

[8]. Kotey. D. A., Gbewonyo, W. S. K., and Afreh-Nuamah, K. High chlorpyrifos

[9]. levels on vegetables in Ghana. Pesticides News 80: 2008. 4-6.

[10]. D. K. Essumameng., D. K. Dodoo., C. K. Adokoh., and E. A. Fumador. Analysis of Some Pesticide Residues in Tomatoes in Ghana. Human and Ecological Risk Assessment, 14: 2008. 796–806

[11]. D. Obeng-Ofori. Residual insecticides, inert dust and botanicals for the protection of durable stored products against pest infestation in developing Countries. 10th International Working Conference on Stored Product Protection. Julius-Kuhn-Archive 42: 2010. 774-788

[12]. P. M. Biney. Pesticide Use Patterns and Residue Levels in Tomato in Some Selected Production Systems in Ghana. M.Phil Thesis, University of Ghana, Accra 2001. 127pp

[13]. W. J. Ntow., J. Huub., P. Gijzen., P. Kelderman., and P. Drechsel. Farmer perceptions and pesticide use practices in vegetable production in Ghana. Pest Management Science. 62: 2006. 356–365

[14]. F. A. Armah. Assessment of Pesticides Residue in Vegetables at the Farm Gate: cabbage (Brassica oleracea) cultivation in Cape Coast Ghana. Research Journal of Environmental Toxicology 5(3): 2011. 180-202

[15]. A. V. Waichman., E. Eve., and N. C. S. Nina. Do farmers understand the information displayed on pesticides product labels? A key question to reduce pesticide exposure and risk of poisoning in Brazilian Amazon. Crop Protection. 26(2): 2010. 576-583

[16]. E. T. Blay., E. O. Monne., E. Gaveh., P. Adu-Amankwah., Baseline survey of city vegetable gardening in Greater Accra. Ghana Journal of Horticulture 5: 2006. 139-148

[17]. Ghanaweb (2013). Faking and Adulteration of Pesticides in Ghana http://www.ghanaweb.com/GhanaHomePage (Accessed: 02/01/2013)