

Farmers' Knowledge and Awareness towards the Use of Agrochemicals in Vegetable Cultivation, Fako Cameroon

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Abstract

Agrochemicals are contemporary, omnipresent tool used in vegetable cultivation. Farmers' knowledge and awareness of the proper usage of agrochemicals are critical for mitigating the negative effects on human health. This cross-sectional study was aimed at assessing the usage knowledge, risk awareness of toxicological and chemical classes, proper handling and use practices for agrochemicals homologated for use in vegetable farming, and the occurrence of health-related symptoms as a result of exposure among these farmers. The study included 93 vegetable growers from agricultural hotspot towns in Fako, southwest Cameroon. The field study, ran from November 2021 to December 2023, using a questionnaire to collect information on farmers demographic, and their knowledge of pesticide classes, and the related risk of associated with the handling of agrochemicals. Results show that all vegetable farmers, particularly those engaged in agribusiness, employ pesticide inputs to maximize production. Six pesticides, two fertilizer types, and one unknown substance were identified. While 23 active compounds were found, the most utilized were abamectin, emamectin (10.46%), dimethoate (9.30%), and ethoprophos (8.13%). Two active chemicals, dimethoate and methalaxyl, are illegal yet remain in circulation. Toxicological classes I and II, with the greatest harmful effect on human health, were the most commonly utilized (64.27%). Thirty-nine percent of farmers never use personal protection equipment when working with agrochemicals, demonstrating a significant gap in knowledge and awareness of agrochemicals and their various applications and handling procedures in the field. The government should implement an intensive specialized educational

program for on-field farmers with incentives in order to promote sustainable agriculture methods that ensure environmental and human safety.

Keywords

Farmers Knowledge, Agrochemical Risk Awareness, Vegetable Cultivation, Agrochemical Use Practices, Health Risk

1. Introduction

Vegetable cultivation in Cameroon is assuming an increasingly vital role beyond commercial, particularly for low-income families living near urban and peri-urban centers (Asongwe, Yerima, & Tening, 2014). It serves as a means of supporting livelihoods through food provision, income generation and employment (Gokowski & Ndumba, 1997). Despite the importance of vegetables, the quality of agricultural products is controlled by the agrochemicals used (Hou & Wu, 2010). Apparently, based on (Sabran & Abas, 2021), in order to maximize profits via efficient and productive techniques, modern agricultural practices rely heavily on agrochemicals, which has affected the environment and human health, as improper use of pesticides is common (Dassou et al., 2023). Climatic conditions in Cameroon are conducive for the proliferation of pre- and post-harvest pests and diseases, causing an annual crop loss in excess of 40% (CREPD, 2019). In order to manage pest and vector-borne diseases, most farmers are highly dependent on pesticide use, which has significantly impacted food production for the increasing world's populations (Boateng et al., 2023). As stated by CREPD (2019), Cameroon imports an estimated 25,000 tons of solid pesticides and 3,000,000 liters of liquid pesticides annually; evidence from Food and Agriculture statistics shows global annual pesticide use of 4.12 million tons (FAO, 2021). While Africa contributes a small percentage of global pesticide use (2%), Cameroon, South Africa and Ghana, are among the biggest consumers of pesticides in Africa (FAO, 2021). However, the increasing demography of Africa and the rapid decline in cultivable lands (Sarker et al., 2021; Gupta et al., 2023), make feeding the growing population via sustainable agriculture a challenging issue (OECD/FAO, 2023), necessitating farmer's dependence on agrochemicals. According to (Amoah et al., 2006), if not appropriately applied, these agrochemicals leave residues on vegetable produce that may hamper the safety of consumers and the farmers via exposure. Conducting farming effectively and efficiently is a useful strategy in eradicating poverty and hunger, a key indicator of sustainable development (FAO, 2021). The use of agrochemicals has led to increased food productions (Popp, Peto, & Nagy, 2013; Alexandratos & Bruinsma, 2012). However, numerous studies show that vegetable farmers are exposed to the chemicals while mixing, loading, mixing or applying through contact with treated crops (Damalas & Eleftherohorinos, 2011; Remoundou et al., 2015). Exposures to other organisms during application,

including humans, are poorly controlled (Damalas & Eleftherohorinos, 2011). WHO (2000), estimated that more than three million farmers in developing countries are poisoned yearly by agrochemicals. The various means of agrochemical handling and use have significant effect on the quality of the environment and health of the population (Gupta et al., 2022). The threat posed by pesticide residues not only depends on the quality and specificity of agrochemicals, but also on farmers' perception and awareness of agrochemicals and their behavior during application (Mondal & Pal, 2023). Conferring to Sabran & Abas, (2021), knowledge and awareness from farmers regarding the associated environmental and health risk linked to agrochemicals is fundamental to ensuring the sustainable use. Majority of vegetable farmers handling agrochemicals do not know the meaning of standard pictograms depicted on agrochemical containers and the harmful effects that they can pose on human health and on the environment (Mondal & Pal, 2023; Sabran & Abas, 2021). The toxicity of an agrochemical and its other properties depends on the frequency of applications, time and method of spraying, climate, vegetation structure, soil type and the non-target species (Resende et al., 2016). Per Khanal & Singh, (2016), smallholder farmers often have small investment budgets, coupled with weak extension services and the lack of training and access to awareness programs on the safe use of agrochemicals. The objective of this study is to assess the level of knowledge and awareness of the various risks associated to agrochemical use practices and patterns among smallholder vegetable farmers within Fako division, in the south-west region of Cameroon.

2. Materials and Methods

2.1. Research Area

Three administrative units within Fako division principally Buea, Tiko and the Limbe rural municipalities (4°14"N and 9°20"E) were selected for this study as demonstrated in Figure 1. The towns of particular interest were Muea, Lysoka, Liongo, Bulu, Sasse, Soppo, Molyko, Bolifamba, Mutengene, Ombe, Mile 14 and Wotutu, as they are known for vegetable cultivation. The climate is Equatorial Guinea type, with relatively stable, monthly mean temperatures of 26°C - 28°C and an average rainfall of 2300 - 3200 mm annually. There are two main seasons; the rainy season which runs from Mid-March to Mid-October and dry season from Mid-October to Mid-March. March is the warmest month of the year (Ajonina, Joseph, & Fonchenalla, 2021; Wannie et al., 2018; Sounders, Sunjo, & Mbella, 2017).

2.2. Research Method

A quantitative method was used for this study with a purposive sampling technique aimed at collecting data and individual information from the sampling population via a semi-structured questionnaire administered by the researcher. Purposive sampling technique is a sampling technique where specific respondents were selected to collect specific information out of the data. The respondents were

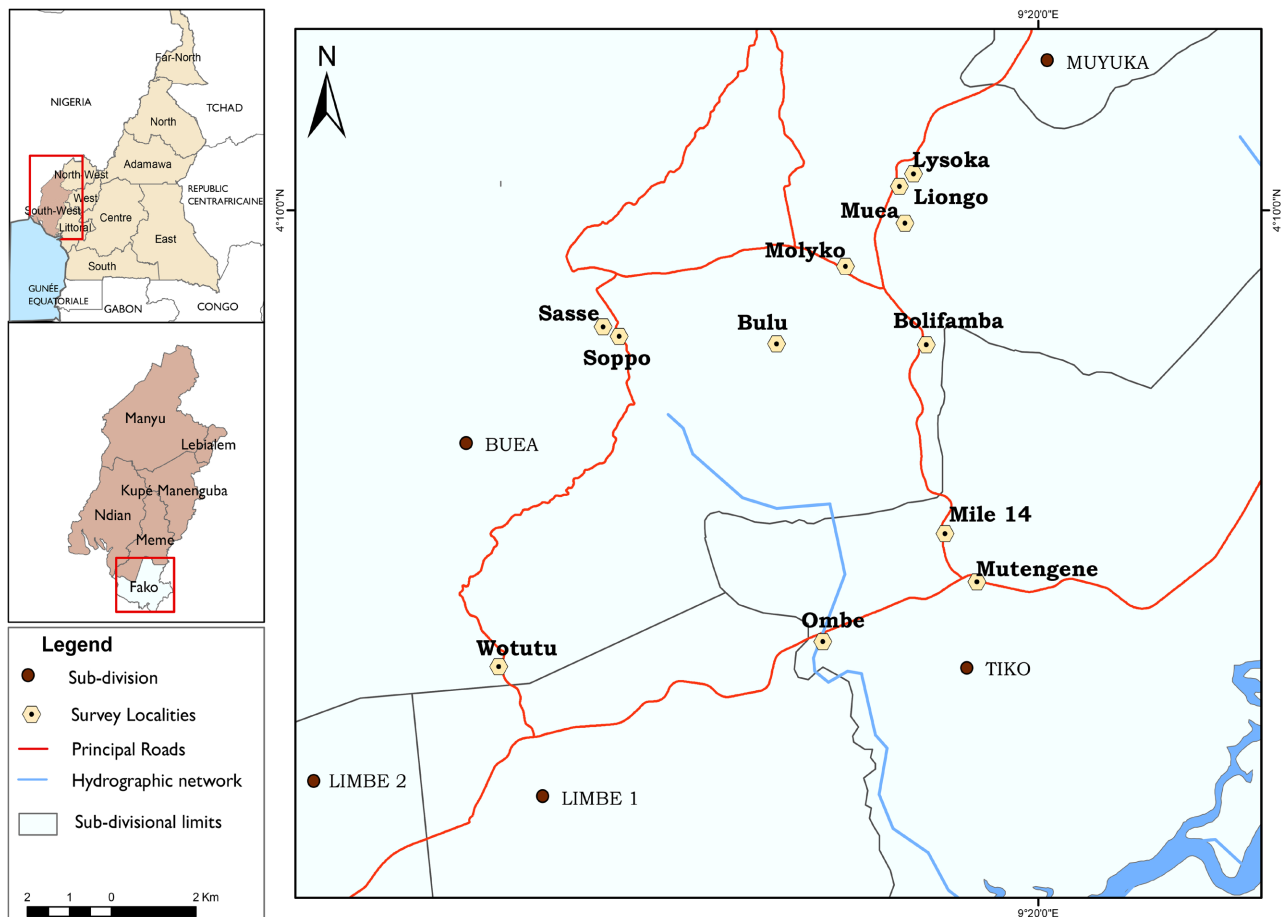


Figure 1. Map of survey localities within Fako division.

required to meet certain criteria like having worked a piece of land for more than ten years, having a piece of land that exceeds 500-meter square and uses agrochemical during the farming process, in order for the objectives of this study involving the vegetable farmers. The questionnaire is divided into two sections, the first section is on identifying and assessing knowledge and risk associated to agrochemical usage by vegetable farmers and the second section is on assessing household vegetable consumption. The questionnaires were designed and administered using the strategy of [Asongwe, Yerima & Tening \(2014\)](#). Whereas identification of the various active ingredients and toxicology class was possible by referencing the identified list of agrochemicals to the list of homologated lists of pesticides in Cameroon ([Minader, 2022](#)).

2.3. Statistical Analysis

Data were analyzed using statistical package for social science (SPSS) software, standard version, release 20.0. Descriptive statistics provided insights into perception, categorizing of identified agrochemicals, application practices among smallholder vegetable farmers and awareness of toxicological classes to obtain the total value, percentages, frequency, average mean and standard deviation. Findings

from this descriptive analysis permitted the researchers to identify variables that influenced the vegetable farmers level of knowledge on agrochemicals used, use pattern and associated environmental and health risk with their usage. While inference analysis was used to present the evaluation of the relationship between sociodemographic and knowledge factors against awareness as in [Boateng et al. \(2023\)](#).

3. Results and Discussion

3.1. Types of Agrochemicals Used in Vegetable Cultivation

The farmer-respondent from all the questionnaires administered, indicated that all vegetable farmers use some form of agricultural input (100%), in the form of agrochemicals as some sort of integrated pest management (IPM) technique in farming. One hundred and fifty-five (155) agrochemicals were identified in the field-survey carried out as shown in [Table 1](#). The results show that 49.7% (77) were pesticides and 50.3% (78) were fertilizer. Six (06) types of pesticides were identified, with insecticides making 63.63%, followed by fungicides with 23.37% and herbicides with 11.68% of the total. 20% of the insecticides were insecticide/acaricide and 2.04% were insecticide/biocide and also 2.04% were insecticide/nematicide.

Table 1. List of Agricultural Inputs registered in the field.

Insecticide	Fungicide	Herbicide	Acaricide	Biocide	Nematicide	Fertilizers	
			77				78
49	18	9	10	1	1	Organic	Inorganic
63.6%	23.3%	11.68%		Others (1.29%)		33 (42.30)	45 (57.69)

From the survey, it was observed that 57.69% of the vegetable farmers prefer using inorganic fertilizers to organic fertilizer, since most of the cultivated vegetable is for economic purposes. Inorganic fertilizers make the leaves of vegetable grow bigger whereas the colossal nature of organic fertilizer limits their potential usage. Vegetable farmers within Fako division from the communities sampled depend heavily on pesticides in managing pests and diseases. Insecticides were the most used pesticides, doubling the rest of the five (05) identified pesticides, followed by fungicides and herbicides. These results are consistent with the results of [Okolle et al. \(2022\)](#). [Okolle, Ijjang & Ngome \(2014\)](#) stated that biotic constraints (pests and pathogens) are the most prevalent threat to crop production, resulting in pre-harvest, post-harvest losses and lower yields. According to [Sharma et al. \(2019\)](#) the most common biotic stresses mentioned by farmers were insects, fungi, mollusks and birds, but in vegetable farming, the main signs/symptoms resulting from pests/diseases damage were skeletonize leaves, leaf curling, holes on leaves

and leaf rots. It is as a result of these, that farmers are obligated to intensively use insecticides (63.63% of total pesticides) to combat pests like the fruit flies, white flies, aphids, mole crickets, grasshoppers, caterpillars, aphids and whiteflies associated with vegetables (Feola, Gallati, & Binder, 2012). Whereas fungicides are used in treating blights associated with vegetables particularly in the dry seasons as expressed by the vegetables resulting in their usage amounting to 23.37%. One other chemical identified is FIXAFORT, used as a sticking substance added to pesticides in order to prevent run-off during agrochemical application during the rainy seasons. These results in **Table 1**, corroborates with the results of Asongwe, Yerima & Tening, (2014) that shows all respondents (100%) of wetland vegetable farmers in the Bamenda municipality, use a variety of these fertilizers (urea, NPK, sulphate fertilizers) which are all of unknown purity. The organic fertilizers frequently used range from poultry droppings to processed organic fertilizers like urea and to AGROVERT products like 20:10:10 and 11:14:46.

3.2. Chemical Classes and Toxicity of Active Ingredients from Identified Pesticides

Twenty-three (23) active ingredients were identified as seen in **Table 2**. The most used active ingredients were Abamectin, (10.46%), Emamectine, (9.30%), Dimethoate and Ethoprophos (8.13%). These were classified into seven distinct chemical classes as in **Figure 2**, namely Avermectin (seed treatment), Pyrethroids, organochlorines carbamate, Phenylamine and Triazines.

Of the twenty-three (23) recorded active ingredients, two (02) were identified as contrabands in Cameroon, including Dimethoate and Methalaxyl with a combined percentage of 11.61% and five (05) were unidentified.

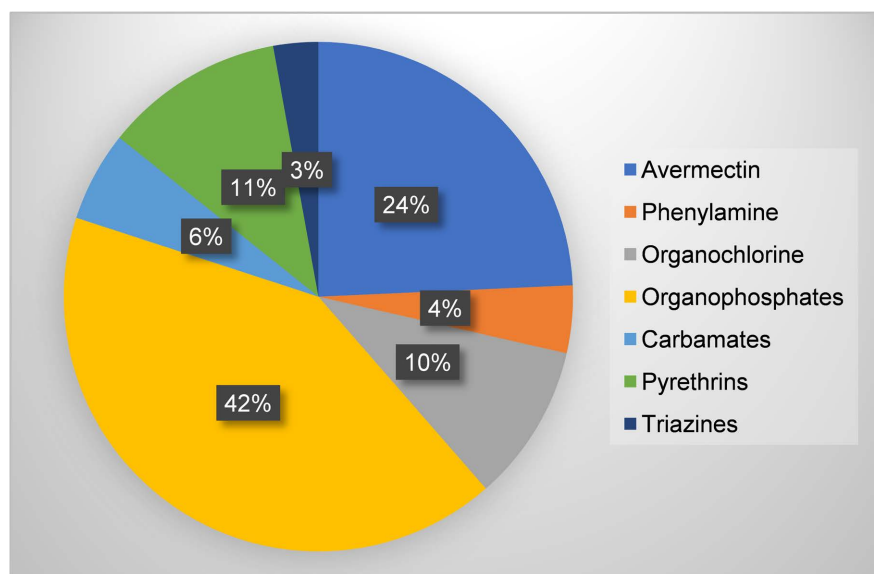


Figure 2. Toxicological chemical classes of pesticides identified in the field.

Table 2. List of identified active ingredients and their percentages used on vegetables within Fako.

NO	Name of active ingredients	Percentage (%)
1	2,4-dichloro-phenoxyacetic acid	2.32
2	Abamectin	10.46
3	Chlorpyrifos	4.65
4	ETHYL	4.65
5	Dimethoate	8.13
6	Imadachlopride	3.48
7	Acetamiprid	6.97
8	Emamectin	9.30
9	Chlorothalonil	5.81
10	Cymoxanil	2.32
11	Pencozeb/Mancozeb	4.65
12	Oxyde de cuivre	1.16
13	Métalaxyl	3.48
14	Ethoprophos	8.13
15	LambdaCyhalothrine	3.48
16	Cypermethrine	3.48
17	Hexaconazole	1.16
18	Profenofos	3.48
19	Propiconazole	1.16
20	Alphaméthrine	1.16
21	Chlorpriphos	1.16
22	Glyphosate	6.97
23	Mefenoxam	2.32

The result in **Table 2**, shows that the most abundant chemical classes of pesticides used among vegetable farmers is organophosphate with 41.42%, followed by the class Avermectin (24.28%), Pyrethroids, (11.42%) organochlorines (10%) carbamate (5.71%), Phenylamine (4.28%) and lastly by Triazines (2.85%) as presented in **Figure 2**. **Figure 3** shows the various toxicological classes of pesticides as defined by WHO (2000), that were identified within the field these vegetable farmers use.

Abamectin, the most popular active ingredient, is used primarily to control mites and emamectin benzoate for the control of lepidopteran (butterflies, moths

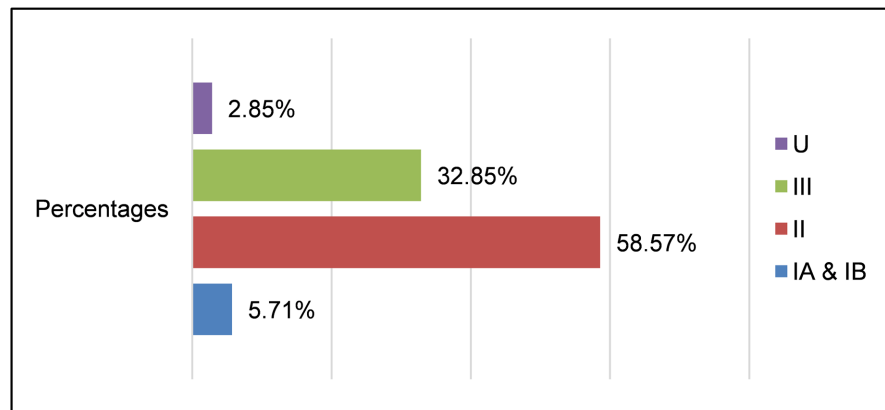


Figure 3. Toxicological classes identified in the survey.

etc.) species in vegetable. This data is not consistent with the list of homologated pesticides in Cameroon by the Ministry of Agriculture and Rural Development (MINADER). From the findings of this research, a combined percentage of 11.61% comprising of two active ingredients Dimethoate and Methalaxyl, are currently banned in Cameroon. These two active ingredients were banned by ministerial decision N°01326/16/D/MINADER/SG/DRCQ/SDRP/SRP banning the importation and homologation of compounds with Methalaxyl in Cameroon and Ministerial Order N°00829/A/MINADER/SG/CNHPCAT of 30 July 2013 prohibiting the use of phytosanitary products containing Dimethoate respectively (Okolle et al., 2022). This result concurs with the reports of SAICM (2020) and the findings of Okolle, Ijiang & Ngome (2014), that despite the regulations in place banned pesticides are still being imported in some countries. It is equally supported by the results of Okolle et al. (2016), noticing the obvious misuse and abuse of pesticides in vegetable production that were either banned or toxic (WHO class Ia or II pesticides) in Table 3.

The toxicological chemical classes show that 41.42% of the pesticides were made up of organophosphate products. Avermectin (24.28%) was mostly used for treating seeds, however was equally used by vegetables in combatting parasitic worms. This result corroborates with that of Ssemugabo et al. 2022, revealing organophosphates as the most used classes of pesticides in vegetable cultivation. However, ten (10%) percent of the vegetable farmers continue to use organochlorine related pesticides. The results in Figure 3 show that majority (64.28%) of the farmers use chemicals that are known to be highly toxic (WHO class I and II) in Table 3 and by nature of their constant usage, it exposes these farmers to the risks associated with each toxicological class. WHO class Ia, Ib and II, are extremely dangerous, very dangerous and slightly dangerous when exposed to. These classes of substances are equally known to be hazardous to the environment and affect soil physical properties. The farmers continue to use these products because of their effectiveness in the field and since from the survey, farmers do not know the meaning of the toxicological classes of these agrochemicals,

which is the reason 64% of the vegetable farmers continue to use these chemicals of class Ia, Ib and II. This result agrees with the findings of Okolle, Ijiang & Ngome (2014), of all the vegetable integrated protection management practices in place, the use of pesticide was the most common which is due to the high efficacy as well as being less labor intensive as compared to weeding out the weed.

Table 3. WHO Toxicological classification of Pesticides (2000).

Category	Description	LD50 (mg/kg)	
		ORAL (By mouth) Solid	DERMAL (By skin) Solid
Ia	Extremely dangerous	<5	<50
Ib	Very dangerous	5 - 50	50 - 200
II	Slightly dangerous	50 - 2000	200 - 2000
III	Can be dangerous	>2000	>2000
U	Probably dangerous	>5000	

3.3. Knowledge and Awareness of Vegetable Farmers towards Agrochemical Usage and Toxicity

With knowledge comes awareness, and awareness depends on the practical applications of acquired knowledge an individual has developed from information exposed to.

From the field survey in **Table 4**, 10% of the farmers have no former education, 35% ending at the primary level, with 40% ending at the secondary level and 15% getting into the tertiary level. When it comes to the knowledge on agrochemical usage, 49% of vegetables farmers got the primary knowledge on the use practices of pesticides and fertilizers from vendors, 20% from fellow farmers and 13% from personal experiences after repeated trial and errors then 14% from reading the information on the packages. The result shows that less than 1% of the vegetable farmers have had any formal training on the utilization of agrochemicals in vegetable farming despite awareness of associated risks. Based on the results from the knowledge of pesticide toxicity, 78% farmers are aware of the fact that it can cause some negative impact to humans, 38% that it is negative to the environment, 45% to the crops and 35% to biodiversity. 11.6% are not aware of the possible entry routes (mouth, nostrils, skin) of pesticides to humans while spraying. Thus 11.6% are not aware of the potential effects of pesticides upon entry into their system despite the fact that they are aware that it does have an effect, however they are not cognizant of the exact consequences. 10% of the farmers are knowledgeable and aware of the different roles and impacts between fertilizers and pesticides, as 56.6% believe pesticides will make the soil more fertile and 25% are convinced that pesticides make the soil less fertile. 20% of participants are not aware of the

possible consequences of eating vegetables with remnants of pesticides on it, whereas 78.3% are aware and knowledgeable of the consequences of eating vegetables with remnants of pesticides. Regarding the use of PPE, 39.6% of the farmers do not use PPE, 1.7% hardly use it, 31.03% do use it occasionally and 27.6% use it always, but none uses the complete PPE.

Table 4. Assessing knowledge and awareness of farmers when handling agrochemicals.

Level of education	Primary 35%	Secondary 40%	Tertiary 15%	No schooling 10%	
Knowledge of pesticide impact (toxicity)	Humans 78%	Environment 38%		Crops 45%	Biodiversity 35%
Formal knowledge on using agrochemicals	Vendors 49%	Package 14%	Peers 20%	Experience 13%	Trained 4%
Knowledge on possible entry routes	Aware 88.4%			Not aware 11.6%	
Knowledge of impact due to exposure	Death 26.6%	Blindness 43.3%	Skin burns & rashes 58.3%	Not aware 11.6%	Sickness 5%
Experiences after consumption of vegetables	Diarrhoea + Vomiting + Nausea 78.3%		Not aware 20%		Others 1.7%
Use of PPE when handling agrochemicals	Always 27.6%		Sometimes + Sparingly 32.73%		Never 39.6%

In order to protect vegetable crops, 100% of the small-scale vegetable farmers use some IPM practices at various growing stages. Regarding the time of agrochemical application, it was observed that 61% of vegetable farmers do apply chemicals in the morning between 6 to 12 noon, with 31% applying between 6 to 9am and 30% between 8 to 12 noon. Whereas 20% of these farmers do not have any specific time of agrochemical application, as 19% do apply in the late afternoons and early evenings between 3 to 6 pm. Concerning the stipulated time gap for agrochemical application before the harvest and consumption, 35% of the vegetable farmers do not respect the time gap as to the specificity of the different agrochemicals, however, 47% do not have any specific time gap, while 10% have time gap of 3 - 5 days and 8% of less than 3 days prior to harvest. Farmer's knowledge about agrochemicals; their usage, their application strategy, their use of PPEs and their perception of the harmfulness of pesticides on human health and on the environment, is vital for the development of a standardized sustainable agricultural management plan for agrochemicals. The study revealed that most respondents (49%) acquired primary information regarding the use of pesticides from agrochemical dealers. This is due to the fact that 45% of the smallholder leafy vegetable farmers are primary school leavers and do not have profound knowledge of the risks linked to these chemicals. The limited level of education makes them gullible to the agrochemical vendors. Furthermore, the proximity of these vendors

to farmers reduces the burden on these farmers as they turn to easily access and buy these products from the vendors. This result is in contrast to those of [Boateng et al. \(2023\)](#) where 89.3% of the farmers obtained information regarding the use of pesticides from extension farmers and [Obiri et al. \(2021\)](#) with 66% were cognizant of the recommended usage practices for pesticides. In Fako, there are little or no extension farmers in the field to train and educate smallholder farmers on the sustainable use of agrochemicals. Giving room for the agrochemical vendors to exploit the gullibility of vegetable farmers into buying chemicals they recommend. 20% of respondents learn about chemicals from their peers that have more experience in the vegetable business and these experienced farmers have acquired their knowledge on pesticide usage via repeated usage and from trial and errors. The 1% farmers that have received formal training on pesticide usage are those dealing with tomatoes and the training was as a result of project's training workshop. However, according to [Ssemugabo et al. \(2022\)](#), some studies show that growers possessing adequate knowledge of pesticide related symptoms still continue to engage in risky practices and from the studies this is the similar situation in the field with farmers.

Protecting crops from pests and diseases is critical to ensuring food security and sustaining livelihood of farmers especially small-holders. 100% of respondents use agrochemicals as a means of protecting crops and combatting pests and diseases, this is because agrochemical usage in vegetable farming for economic purposes guarantees high yields and reduces losses in crop from pests while ensuring profitability. However, these farmers disregard the impact of wind direction, as no consideration is given to this environmental aspect during agrochemical application, specifically during the raining season, as all the tomato vegetable farmers apply at the occasion of any given sunshine whereas for the leafy vegetable farmers, farming activities is widely practiced during the dry season still with little consideration of wind direction. Environmental aspects are not taken into consideration and with 41% of the farmers not using PPE, there is high probability of inhalation and even dermal penetration of agrochemicals during application, since none of the vegetable farmer were observed to be using all the PPEs during spraying. This result is in contrast to [Boateng et al. \(2023\)](#), were approximately 82% of the respondent agreed to using PPEs all the time despite the inconvenience, even though this was understood to be partial protection as they did not cover all the part parts during application, whereas in Fako it is as a matter of convenience and availability. Considering the timing of the day chosen for agrochemical application the 61% which applies during the mornings and the 19% that applies in the later part of the day, pick this period as a result of convenience and less possibility of getting tired early. Here it is not the possibility of losing the agrochemicals via evapo-transpiration or due to wind that governed their decision, instead their decision was linked to reducing stress and tiredness from not working under the sun. When looking at the time gap for pesticide application before harvesting, 35% respondents were careless and 47% extremely carefree with 8% being non-challan

regarding human health. The carelessness on the part of these farmers leads to the sale of vegetables with remnants of chemicals on them without allowing it the appropriate time for the active ingredients to be broken down. This reveals that despite the awareness of some of the risk linked with agrochemicals, financial motives will always be the overlaying force directly dictating the attitude of leafy-vegetable farmers, thus as Feola, Gallati, & Binder, (2012), stated enhancing knowledge through education and training might not be enough to mitigate potential pesticide-related disease risks. The reason for this is because most vegetable farming around urban areas is for profit and farmers tend to be careless about their usage long as it guarantees profitability. This result is in congruence to that of Sharma et al. (2019), which shows with increasing rates of use, most users act as an “accelerator” for pesticides entering the environment thereby seriously jeopardizing the health of consumers.

4. Conclusion

The research focused on identifying and characterizing agrochemicals used by vegetable farmers and understanding the perception of their associated health risks. The study shows that unsafe pesticide practices are prevalent not only in vegetable farming but also across the national territory, are controlled by the effectiveness of active ingredients, their availability in the market and most importantly the cost prices of these agrochemicals. Farmers’ knowledge on agrochemicals varies based on the vegetable types cultivated. However, understanding pesticide toxicology and proper application practices is most crucial to mitigate risks to human health and increasing overall profit, of it positively contributing to livelihood well-being. Thus, knowledge-related interventions can improve awareness and use practices among vegetable growers. Since safeguarding human health and the environment requires a significant shift in awareness toward agrochemical use practices. Thorough training and education are essential to addressing the unsustainable agrochemical use that is largely profit driven. Thus, embedding voluntary sustainability standards into trade agreements is crucial for ensuring long-term mutual benefits. Best practices can be copied from the other communities that have adopted organic and green production practices, avoiding pesticides. Integrating traditional and modern methods will reduce reliance on agrochemicals, benefiting health and the environment. Despite existing conventions and laws, weak implementation persists. Continuous monitoring, sensitization, and stakeholder training are essential to improve pesticide practices and safeguard health.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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