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Small-Scale Tomato Cultivators' Perception on Pesticides Usage and Practices in Buea Cameroon

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Abstract

It has been shown that farmers with limited knowledge of the use and safe handling of pesticides may suffer exposure which results in adverse health effects. In Buea, Cameroon, small-scale tomato farmers commonly use pesticides for pest control. Information was obtained from these tomato farmers to determine the extent and types of their pesticide use, their knowledge of pesticide use and effectiveness, and their perception of potential harm resulting from pesticide use. A standardized questionnaire, interviews, field observations and an analytical ranking game were used to describe the pesticide use of 93 tomato farmers. Many farmers (47.6%) used pyrethiod and organophosphorus insecticides and identified these chemicals as the most effective in pesticide control; these are WHO Class II pesticides which are the most hazardous to humans. Most farmers (83.8%) used knapsack sprayers to apply pesticides, with 76.3% using no or partial personal protective equipment (PPE). It was notable that 55.5% of farmers expressed no concern regarding the wind direction (pesticide drift) during spraying. The results showed a significant association between the method of pesticides application and farm size (P < 0.001). Most farmers (85.0%) reported at least one symptom of acute pesticide poisoning following spraying. This study revealed that the tomato farmers have a high exposure to pesticides secondary to inadequate knowledge of the safe and judicious use of pesticides. Strategies that provide training on the appropriate use of pesticides, how to reduce exposure to and health risks of pesticides and alterna-

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tive options of pest management and control are required. The study also raised concerns that further control of the sale and distribution of pesticides may be indicated.

Keywords

Small-Scale Farming, Tomato Cultivation, Pesticides Poisoning, Cameroon

1. Introduction

Pests are known to negatively impact crop production as well as the health of communities and nations. Farmers have long sought ways to control pests and plant disease. In Cameroon, farmers have traditionally used wood ash and animal droppings (mixed with water) to control pests and plant disease. However, these methods are ineffective and do not improve crop production.

As in many African Nations, Cameroon has seen a population shift from rural to urban areas which have increased the demand for vegetables in towns and cities. To meet this need, small-scale farmers are now cultivating their crops in semi-urban and urban areas. These small-scale farmers have turned to pesticide use which they recognize will reduce crop loss and improve crop production [1]. Farmers consider pesticide use to be labor saving, as well as an effective and efficient tool which controls pests. Yet, farmers and their communities are also raising concerns not only about the environmental impact, but also the public health effect upon their families and community.

Farmers are often exposed to increased health risks through the mixing, application, and disposal of pesticides. This exposure can lead to pesticide poisoning causing short- and/or long-term health effects. In 1986, the World Health Organization (WHO) estimated that 1 million cases of pesticide poisoning were reported annually which resulted from farm use; approximately 200,000 (20.0%) of these cases resulted in death [2]. The causes of death are often attributed to improper handling and management of pesticides by farmers who lack adequate knowledge of the common guidelines for safe use of pesticides, including use of personal protective equipment (PPE). Health risks are not limited to farmers. In Ghana, pesticides residues have been found on food, as well as in lake and reservoir water, thus raising concern of pesticide exposure to the general public [3]. In many low-resource countries where farmers face financial difficulties, pesticide use is further complicated by the farmers using pesticides indiscriminately and incorrectly to increase crop production often without adequate knowledge of pesticide use. It has been shown that increasing the availability of agricultural extension service programs can increase farmer's knowledge of appropriate and safe pesticide use [4]. Finally, these farmers use defective or malfunctioning spraying equipment, do not correctly wash the equipment, reuse pesticides containers for food and water storage, and store toxic chemicals that are banned or restricted for later use [5].

The routes of human exposure and pesticide poisoning are through inhalation, ingestion, and skin absorption [6], which usually occur during spraying, weeding, harvesting and early re-entry to fields after spraying. The pesticide exposure risk increases among farmers in the tropical areas where temperatures and humidity are higher and the uptake of pesticides is favored due to an increase in body temperature and sweating [7]. Ill-health resulting from pesticide exposure may affect the overall daily performance and crop productivity of farmers in low-income settings where small-scale agricultural practices are mostly performed by individual farmers and their family members.

The tomato (*Solanum lycopersicum*) is one of the most widely grown vegetables in the world [8] and consumed in many African meals. It is nutritious and can be processed and combined in many different dishes and eaten in different ways, such as a tin paste, eaten as a fresh vegetable, and made into tomato juice, sauce, or soup. The tomato is known for its nutritive value. It is a low-calorie vegetable, low in fat, has no cholesterol, and is an excellent source of antioxidants, dietary fiber, minerals, potassium, and vitamins. Dieticians and nutritionists often recommend tomatoes in cholesterol controlling and weight reduction diet-programs. Eating tomatoes has been promoted as helping to prevent some human diseases (cancer and heart diseases), and improving the immune system response (anti-tumor immune response) [9]. Therefore, the tomato is a recognized and important food source.

In recent years, Buea has experienced an increase in population resulting in an increased demand for tomatoes.

This has caused a tomato shortage and led many small-scale farmers to change to tomato cultivation, even though they had limited knowledge on tomato farming techniques. Buea is an ideal environment to grow tomatoes, because the land has streams and springs which facilitate irrigation by running down the mountain slope of the municipality. In Buea, tomato cultivation has benefited the economy by increasing both community employment and the income of small- and medium-scale farmers. The tomatoes grown are used for household and domestic consumption, and are in demand in neighboring areas of Cameroon and other nations. Yet, in Cameroon, the production of tomatoes has been shown to be greatly impacted by different types of pests [9]. This problem has prompted farmers to use pesticides as a means to control pests and improve their crop production.

Farmers often regard pesticides to be the primary solution to boost their crop productivity, but the farmers' increasing dependence on pesticides has attracted little attention in Cameroon. The increased crop productivity is especially appreciated by the small-scale farmers, but there is also increasing concern expressing about the health effects of pesticide use within the communities. This study was performed to determine the degree and types of pesticide use, the Buea farmer's reliability on chemicals to control pests and to assess the knowledge, and perception of farmers on pesticide effectiveness and potential health risks.

2. Methods and Materials

2.1. The Survey Site

The study site was located within the Buea municipality which is in the South West Region of Cameroon. Buea municipality is on the leeward site of Mount Cameroon, situated at 247.789˚N, 58.24˚S, and some 530 m above sea level. The temperature varies between 17˚C to 32˚C. The rainy season is from late March to early November, with an annual rainfall of above 4000 mm. There is a short dry season from mid-November to mid-March. Most of the tomato cultivation is done during the dry season due to the favorable climatic conditions. This survey was performed from September 2012 to November 2013 during both dry and rainy seasons.

2.2. Methodology

A standardized questionnaire, interviews, field observations and an analytical ranking game were used to collect study information. The questionnaire consisted of 30 questions which addressed the following: demographic and life style data, farm details, work history, and pesticide use and practices. The questionnaire was developed from previous studies [10] [11], and modified to suit the study area. The questionnaire was then reviewed by experts at the Institute for Occupational and Environmental Health, Korea University (Seoul, Korea) and an agricultural expert from the Mutegene Farmers' Cooperative Union (Mutegene, Cameroon). Modifications were made in response to these expert's suggestions and the questionnaire was pre-tested among 22 volunteer farmers. Adjustments were made with the remaining survey questions found to be valid and understood by the farmers.

The formal interview consisted of a structured guide containing multiple choice questions and administered by the authors. This information assessed the farmers' perception of pesticides use and resulting health risks or hazards.

Field observations were accomplished by the principal author. The farmer provided their farm location during the interview and gave permission for the visit. A general time frame for the visit was given, but an exact date was not identified. This allowed the farmers' day to day pesticide use and practices to be observed without change or bias by the farmer in anticipation of the visit.

An analytical ranking game was used to assess the farmers' perception of pesticide use and health risk. This tool has been used in previous studies [12] [13] and consists of a game in which the farmers and/or their associated workers identify different types of the pesticides they use through the labeling on the pesticide containers. In those cases where a farmer could not read, one of the family members' or farm workers assisted, to ascertain that all participants knew the labeling brand. The farmer's knowledge and recognition of each pesticide was determined. The unfamiliar pesticide containers were noted and removed from the game. The remaining and familiar pesticide containers were then put into two groups, "effective and ineffective". The farmers were asked to identify which pesticide they considered to control pests best and least. The least effective pesticides were excluded from the game, and the farmer was asked to rank the effective pesticides on a scale of 1 to 5 (1 = most effective and 5 not effective) and provide reasons for the ranking. The same containers were used by the farmers to rank the pesticides by their perceived hazards and health risks and to identify the reasons for their choices.

Table 1 presents the ranking criteria for pesticide effectiveness and hazard.

Criteria for participation included the farmer must have lived upon and practiced pesticide use on their farm for a minimum of 3 years, own/rent a tomato farm with a size between ≤200 m^2 to 900 m^2 within the Buea municipality, and able to communicate in either English, French, "pidgin English" or the local language (Bakweri).

Participants were recruited with the assistance of community leaders, churches, and local groups in the study area. Letters were sent to each of these entities which contained a clear explanation of reasons for the study, study objectives, inclusion criteria, consent to participate, and voluntary participation. These leaders and groups made announcements to the general public or community gatherings for a month. Those farmers who expressed interest in participation were invited to meet at the community leaders' residence, group meeting locations, or church premises. At these meetings, the principal investigator reviewed the study and explained the content. If the farmer wished to participate, the consent form was signed, and the questionnaire was given to complete. Both the consent and the questionnaire were fully explained to ascertain the farmers understanding. All participants spoke "pidgin English" which is the commonly used language in the South West region. Those participants who could not read came with a family member or friend to assist in understanding each question and how to complete the questionnaire. The principal investigator also followed up with those farmers who could not read English, and translated the questionnaire into their preferred language to make sure the questions were fully understood. The farmers returned completed questionnaires directly to the principal investigator or through their community leaders or groups.

Of the 98 farmers who volunteered to participate in the survey, 3 dropped out of the study due to travel difficulties. This left a total of 95 participating farmers. As a quality control measure, all questionnaires were checked and double-keyed to ensure the questions were answered. Two questionnaires had missing values and were excluded from the study. This left a final total of 93 farmers who successfully completed all aspects of the study.

Data analysis was performed using statistical software package IBM SPSS 21.0. A descriptive statistical analysis was done to generate frequencies, tables, and figures. A Chi square test was performed to identify possible associations with a p-value of <0.05 considered to be statistically significant.

Administrative clearance to perform the study was obtained from the District Medical Officer. Community support and concurrence was obtained from community leaders and groups, and exhibited by their assistance in recruitment and study management.

3. Survey Results

3.1. Participant Demographics

The farmer's demographic information is presented in **Table 2**. The farmers were mostly male (96.7%) and married (93.5%). Their mean (SD) age was 46 ± 9.2 years, with a range of 28 - 60 years. Most farmers (39.8%) had no formal education and have spent an average of 16 years as tomato cultivators (range 3 - 24 years). The majority of the farmers (41.9%) owned or rented farms with a size over 601 m^2.

3.2. Types of Pesticides Used

During the analytical ranking game, the farmers identified 28 pesticides they used with 12 being most commonly used. These 12 pesticides were identified in a total of 483 responses, as multiple responses were accepted among farmers. Insecticides (54.7%) were most frequently identified, followed by fungicides (22.8%), and herbicides (19.3%). Sixteen chemicals (3.3%) could not be classified. **Table 3** exhibits these 12 major pesticides with grouping by their trade names, active ingredient, chemical group and WHO chemical hazards category with class II (moderately hazardous) and class III (unlikely to cause hazards).

3.3. Pesticides Availability, Use and Management

The majority of the farmers (91.4%) said that they were dependent upon chemical control of tomato pests. This dependency was encouraged and supported by easy access to pesticides within Buea municipality with 80% of farmers acquiring from local pesticide vendors' shops and 20% from general shops. Pesticides were available in liquid containers, ranging from 1 to 5 liters, and in powder sachets, ranging from 0.5 kg to 25 kg. Some vendors

Table 1. Ranking of pesticides levels and description using the ranking game.

Ranking	Description	Ranking	Description
Effectiveness		**Hazardous**	
1	Very effective and kills all pests, 80% - 100%	1	Very hazardous and could lead to death, hospitalization or long term effects
2	Effective and kills all pests, 50% - 80%	2	Hazardous and may cause a short illness or require a visit to a physician
3	Moderately effective and kills pests, ≤50%	3	Moderately hazardous may lead to vomiting, dizziness, confusion or blurred vision , skin itches
4	No effects on pests	4	Least hazardous and may cause some dizziness, tiredness, light fever or headache
5	Make the situation worse	5	No effects

Table 2. Characteristics and distribution of farmers.

Dimensions	Frequency, (range), (%), mean ± SD
Demographic characteristics	
Male	90 (96.7)
Age (years)	45.5 ± 9.2 (28 - 60)
Female	03 (3.2)
Age (years)	45.3 ± 8.4 (34 - 54)
Marital status	
Married	87 (93.5)
Single	06 (6.5)
Educational level	
No formal education	37 (39.8)
Primary	33 (35.5)
Secondary	17 (18.3)
Post secondary	06 (6.5)
Years as a farmer	16.3 ± 4.8 (3 - 24)
Owned or rented farm size	
≤200 m^2	06 (6.5)
201 m^2 - 400 m^2	23 (24.7)
401 m^2 - 600 m^2	25 (26.9)
601 m^2 - 800 m^2	39 (41.9)

sell pesticides in smaller quantities of unlabelled containers to enable the farmer to purchase pesticides at a decreased cost. Most of the pesticides were from the; Pyrethoid, Organophosphorus, Organochlorine, Carbamate, Benzimidazole, Acylanine, Glycine derivative, Bipyridylium and Denitroaline chemical groups. Many farmers (94.6%) used more than one pesticide on their farm with 50 g/l Cypermethrine, Mancozeb, and Glyphosate being the most common chemicals identified.

Table 4 presents the farmer's use of pesticides with most of the farmers indentifying the possibility of pest infestations as the main reason for the use of pesticides on their farms. Therefore, pesticides are used for prevention verses only when pests are observed. A few farmers (5.0%) did continue to use wood ash and animal droppings for pest control by sprinkling the mixture over their vegetables when they cannot afford to purchase pesticides.

Most farmers (83.8%) used knapsack sprayers to apply the pesticides, with 76.3% using no or partial PPE. Over half of farmers (55.5%) said they did not consider the wind direction (pesticide drift) during spraying. Many of these farmers (66.7%) disposed used pesticides containers on their farms. The farmers (65.6%) also

Table 3. Major pesticides used by tomato cultivators in Buea.

Category of pesticide	Trade name	Active ingredient (s) (AI)	Chemical group	WHO chemical AI hazard classification	Frequency (%) of farmers responses
Insecticides					
	Cypercal® 50EC	50 g/l cypermethrine	Pyrethiod	II	70 (14.5)
	Parastar® 40EC	20 g/l imidachlopride + 20 g/l lambdacyhalothrine	Pyrethiod	II	63 (13.0)
	Pyriforce®	600 g/l chlorpyriphos-ethyl	Organophosphorus	II	50 (10.4)
	Dimex® 400EC	400 g/l dimethoate	Organophosphorus	II	47 (9.7)
	Thionex® 35R EC	350 g/l endosulfan	Organochlorine	II	34 (7.0)
Sub total					264 (54.7)
Fungicides					
	Dithane T&O	Mancozeb	Carbamate	II	38 (7.9)
	Topsin M	Thiophanate-methyl	Benzimidazole	II	35 (7.2)
	Apron[4]	Metalaxyl-M	Acylalanine	II	22 (4.6)
	Cleary's 3336	Carbendazim	Benzimidazole	II	15 (3.1)
Sub total					110 (22.8)
Herbicides					
	Roundup	Glyphosate	Glycine derivative	III	39 (8.1)
	Gramoxone	Paraquat dichloride	Bipyridylium	II	32 (6.6)
	Corral G	Pendimethalin	Dinitroaline	III	22 (4.6)
Sub total					93 (19.3)
Unclassified					16 (3.3)
Total					483 (100)

WHO classification class II = moderately hazardous, III = slightly hazardous.

disposed the water used in pesticide application and the water used to wash knapsack sprayers upon their fields and in nearby streams. Many farmers (63.4%) returned to their farms within 48 hours after spraying. Most farmers (82.8%) do practice safe methods of pesticides storage after procurement. The primary source of pesticide information was from local pesticide vendors. It was found that the pesticides were not labeled when these vendors repackaged the pesticides in smaller amounts. Most farmers (85.0%) reported symptoms of acute pesticide poisoning after spraying, with weakness (84.9%), and dizziness, headache or fever (67.7%) most often identified. Many farmers said they smoked (47.3%) while spraying pesticides, ate (66.7%) on their farms after spraying, and did not wash their hands (67.7%) with soap and water after spraying. The majority of farmers (87.4%) washed their farm clothes with their family wash, which raises the possibility of cross-contamination.

3.4. Seasonality, Number of Spraying Times, Disease and Pest Perceived by Tomato Farmers

Table 5 shows that all farmers participated in tomato cultivation during the dry season. This was due to favorable weather conditions which limited the number of spraying required to 10 - 20 times. The farmers said this was more cost-effective as opposed to cultivation in the wet/rainy season when spraying was required between 30 - 40 times secondary to the higher number of pests and disease infestations. Less than 15% of the farmers cultivated tomatoes in the rainy season.

Table 6 displays the most commonly encountered tomato diseases experienced by the farmers during the wet and the dry seasons. The most common diseases were; late blight, early blight and bacterial wilt caused by *Pytophtora infestans*, *Alternaria solani* and *Pseudomonas solanacearum* respectively. The farmers identified the fruit fly (76%), fruit worm (48%), sweet potato whitefly (41%) and aphids (28%) to be the most common pests affecting tomato production.

Table 4. Description and distribution patterns among 93 tomato farmers on pesticides use and management in Buea.

Indicator	Frequency of respondents N (%)	Indicator	Frequency of respondents N (%)
APPLICATION OF PESTICIDE AND MANAGEMENT		**STORAGE OF PESTICIDES AND DISPOSAL OF USED CONTAINERS**	
Practice of personal protection		**Storage after purchase**	
Near complete protection[a]	22 (23.7)	Safe practices	77 (82.8%)
No or partial protection[*b]	71 (76.3%)	Unsafe practices	16 (17.2%)
Equipment use		**Disposal of used pesticide containers**	
Knapsack sprayer	78 (83.9%)	Discarded on farms	62 (66.7%)
Hand sprinkling	15 (16.1%)	Take home and washed for reuse	8 (8.6%)
Own a sprayer		Buried on the farm	7 (7.5%)
Yes	37 (39.8%)	Discarded on neighborhood fields	6 (6.5%)
No	56 (60.2%)	Burned on farm	5 (5.4%)
Method of spraying		Discarded in municipal garbage	3 (3.2%)
In wind direction	34 (36.6%)	Sold to pesticide vendors	2 (2.2%)
No consideration	52 (55.9%)	**SOURCES OF FARMER'S KNOWLEDGE OF PESTICIDE USE**	
Against the wind	7 (7.5%)	Pesticide vendors	78 (83.9%)
Timing of pesticide application[c]		Farming groups and friends	44 (47.3%)
Immediately after transplanting	50 (53.8%)	Pesticide labels	36 (38.7%)
Upon presence of pests	70 (75.3%)	The media	2 (2.2%)
Increased degree of pest infestation	42 (45.2%)	Other sources	7 (7.5%)
Other	22 (23.7%)	**SIGNS & SYMPTOMS OF ACUTE PESTICIDE POISONING AFTER SPRAYING[c]**	
Field re-entry after spraying		Weakness	79 (84.9%)
72 hours and greater	24 (25.8%)	Dizziness, headache and/or fever	63 (67.7%)
48 - 72 hours	10 (10.8%)	Skin irritations	29 (31.2%)
Less than 48 hours	59 (63.4%)	Blurred vision and/or eye itching	15 (16.1)
Care of sprayer after use		Vomiting and/or stomach discomfort	6 (6.5%)
Wash sprayer		None	14 (15.1%)
Yes	88 (94.6%)	**PERSONAL AND LIFE STYLE FACTORS**	
No	5 (5.4%)	Drink alcohol	81 (87.1%)
Disposal of wash water from sprayer		Smoke tobacco	44 (47.3%)
On farm	22 (23.7%)	Washes hands after spraying with water only	63 (67.7%)
On nearby fields/stream	61 (65.6%)	Wash hands after spraying with soap and water	30 (32.3%)
On home field	7 (7.5%)	Eats on farm after spraying	24 (25.8%)
Other	3 (3.2%)	Smokes during spraying	44 (47.3%)
		Mix and wash farm clothes with other cloths	77 (82.8%)
		Treats and washes farm clothes separately	16 (17.2%)

[a]Wear long sleeves shirts and long pants, use gloves and mask; [b]Wear short sleeves shirts or t-shirt and long pants, short pants and long sleeves shirt, mask and no gloves, gloves and no mask; [c]Require multiple responses per item express over the total respondents for the items; [*]No farmer reported wearing boots or eye glasses during spraying.

Table 5. The number of pesticide sprays applied in each season among small-scale tomato farmers in Buea.

Season	Month	Number of sprays	Mean of intervals spray days	% of participants
Wet/rainy	March - June	20 - 30	7	15
	July - October	30 - 40	7	10
Dry	November - December	<10	14	100
	January - February	10 - 20	14	100

Table 6. Major tomato diseases and different pests perceived by farmers.

Disease	**Pathogens**	**Frequency (%) respondents**		**Pest**	**Frequency (%) of respondents**
		Dry season	Rainy/wet season	Fruit fly	76
Late blight	*Pytophtora infestans*	17	60	Fruit worm	48
Early blight	*Alternaria solani*	36	11	Sweet potato whitefly	41
Bacterial wilt	*Pseudomonas solanacearum*	22	9	Aphids	28
Bacterial canker	*Clamvobacter michiganensis* subsp.	12	7	Others	16
Root knot	*Meloidogyne* sp.	6	5		
Damping off	*Rhizoctonia solani*	4	3		
Others	*Pythium* sp.	3	5		

3.5. Possible Association of Some Farmers' Variables and Pesticides Outcomes

3.5.1. Age and Possible Poisoning Cases

Figure 1 shows the trends in pesticides poisoning signs and symptoms among the different age groups of the farmers. Young farmers (57.2%) were defined as aged 36 years and less; older farmers were identified to be 37 and more years.

Although more younger men reported symptoms of acute poisoning, only one symptom (weakness) reached statistical significance ($p < 0.5$). It was significant that more older men reported no symptoms than the younger men.

3.5.2. Farm Size and Method of Application

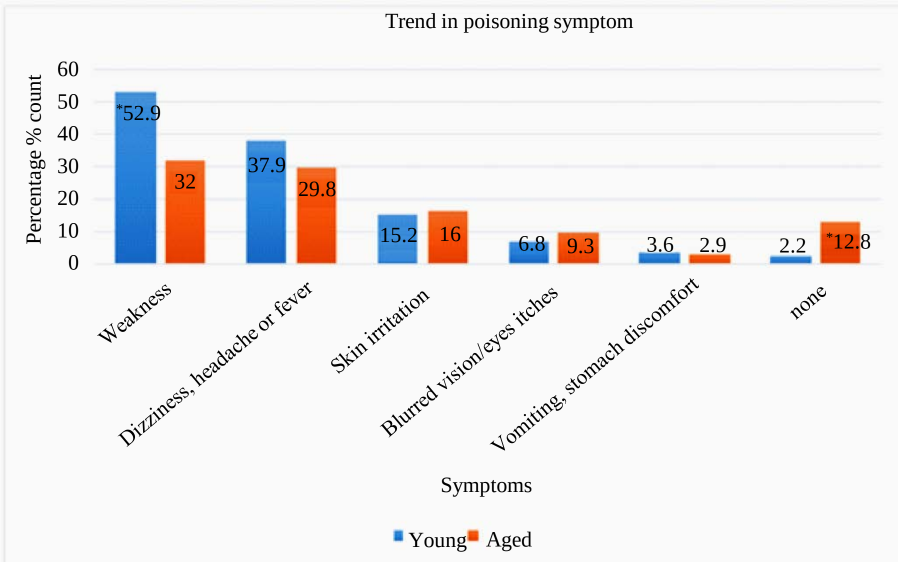
Most of the farmers (83.8%) used the knapsack as their major equipment for pesticides application with 74.7% of these farmers having farm sizes between 401 m^2 to 800 m^2. As shown in **Figure 2**, Knapsack use increased as the farm size increased.

3.5.3. Perceived Ranking of Pesticides Effectiveness and Hazards

Table 7 shows the different ranking of four pesticides perceived by farmers as very effective and extremely hazardous. All farmers thought 50 g/l cypermethrine to be completely effective to control pests. All farmers rated 50 g/l cypermethrine and 20 g/l imidachlopride + 20 g/l lambdacyhalothrine as extremely hazardous. Some farmers thought that specific pesticides caused more problems with their crops while having no toxic effects. It was found that the farmers often did not view pesticide toxicity to be associated with pesticide effectiveness.

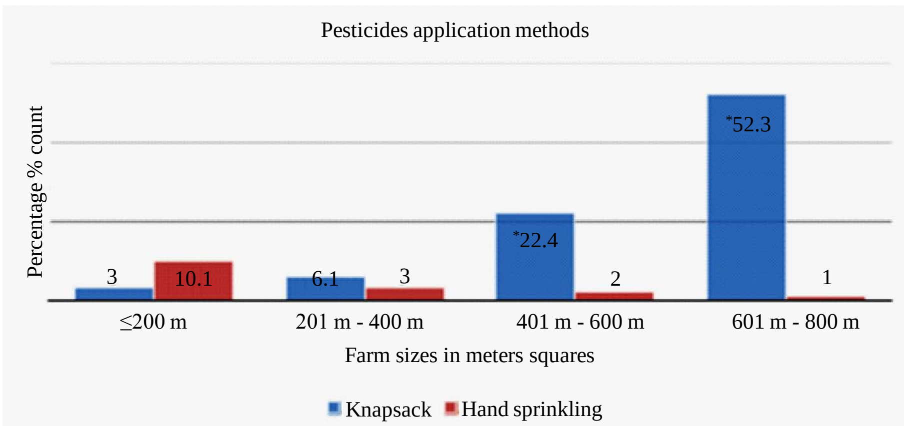
3.6. Challenges and Some Common Beliefs Perceived by Small-Scale Tomatoes Farmers in Buea

Table 8 shows the challenges identified by the farmers. Pests, plant diseases and the high cost of pesticides were perceived as the major difficulties faced by the farmers. The farmers also identified some common beliefs regarding pesticides, including that pesticides affect humans only through specific entry points and that pesticides affect only the old or those with weak immune system ("people with weak blood"). It was also a common finding that some of the farmers attributed illness resulting from pesticides poisoning to some other cause, because



*Signigicant at $p < 0.05$.

Figure 1. Reported percentage distribution of pesticides poisoning symptoms between the young and the aged group.



*Signigicant at $p < 0.05$.

Figure 2. The trend in the different methods of pesticides application.

Table 7. The levels of ranking of pesticides effectiveness and hazards.

Pesticides (chemical active ingredients)	Levels of effectiveness[i]					Total participants	Mean levels	Pesticides (chemical active ingredients)	Levels of hazards[ii]					Total participants	Mean levels
	1	2	3	4	5				1	2	3	4	5		
50 g/l cypermethrine	51	15	3	1	0	70	1.3	50 g/l cypermethrine	66	7	3	0	0	76	1.2
20 g/l imidachlopride + 20 g/l lambdacyhalothrine	42	10	9	1	1	63	1.5	20 g/l imidachlopride + 20 g/l lambdacyhalothine	53	4	2	1	0	60	1.2
600 g/l chlorpyriphos-ethyl	36	8	3	1	2	50	1.5	600 g/l chlorpyriphos-ethyl	44	8	1	1	1	55	1.3
400 g/l dimethoate	33	6	4	3	1	47	1.6	400 g/l dimethoate	41	9	1	0	1	52	1.3

[i]Effectiveness level: 1 = extremely effective, kill all pest, 80% - 100%; 2 = effective, kill all pest, 50% - 80%; 3 = moderately kill all pest, 50% - 80%; 4 = least effective, kill pest, ≤50%; 5 = make situation worse. [ii]Hazard level: 1 = highly hazardous; 2 = hazardous; 3 = moderately hazardous; 4 = lest hazardous; 5 = no effects.

Table 8. Reported farming challenges and common beliefs about pesticides and use among small-scale tomato farmers in Buea.

Challenges	Total respondents/(%)	Perception about pesticides
Insects pest	72 (77.4)	Pesticides are harmful only under certain conditions and entry points
Plant diseases	68 (73.1)	Pesticides harm mostly some people like, the old and people with weak immune system
High cost of pesticides	62 (66.7)	Pesticides are harmless to human
Fluctuating weather conditions	61 (65.6)	Pesticides are harmful but their preventive methods can cause more harm than good
Limited storage life of tomatoes	58 (62.4)	Farmers think they are already taken enough precautions
Lack of pest resistant tomatoes	51 (54.8)	Farmers suffer from ill-health from pesticides but they attribute it to something else other than the pesticide
Uncertainty in market situation	48 (51.6)	
Dampening-off of seedlings in nurseries	33 (35.5)	

they had taken enough precautions to protect themselves. Finally, some farmers said that pesticides are specifically used to treat plants and kill insects, and therefore can have no effect upon humans.

4. Discussion

In Africa, farmers have been shown to apply pesticides more frequently with the hope of acquiring better results [14]. African farmers have also been shown to lack knowledge on the appropriate techniques and management of pesticides or alternative ways to control pests which could be addressed by instituting agricultural extension service programs [15]. In many African countries, governmental programs have encouraged the use of pesticides with a focus on crop and production yield, but without giving serious consideration of the environmental and health risks consequences [16]. These policies encourage many farmers to purchase and use pesticides on their farms with little or no knowledge of the safe use and management of pesticides.

The same situation was also found in Buea, where small-scale tomato farmers identify a high dependency on different formulations and combinations of pesticides as the major means to control pest and plant diseases on their farms.

Some farmers still practice the traditional methods of applying a mix of wood ash, animal droppings, and water to their crops, removing weeds with hands, cutlasses and hoes, and harvesting what is left after pests and diseases infestation at the end of each planting season. These traditional farming practices are not common in Buea.

Insects have been identified as a major hindrance to tomato production in this area [9]. Buea farmers are very aware of the damages caused by pests to tomato production which has led to almost all small-scale farmers to use pesticides as the major means to control pests and plant diseases. Unfortunately, no Buea farmer was able to identify receiving any formal training on the suitable choices of pesticides and their proper application. This leads to concerns that many farmers use the chemicals incorrectly and unsafely which are supported by this study.

Pesticides are expensive, especially for small-scale farmers. The use of pesticides has been encouraged by pesticide vendors who divide pesticides into small sachets and containers which are sold to the farmers without labeling [17]. This practice is worrisome for correct and safe use of pesticides is extremely important and the directions on the label are essential to providing information addressing safe and effective pesticide use. Many countries mandate that pesticides are labeled with required instructions and warnings.

In the analytic rating game, the farmers identified 28 pesticides being used with insecticides being most used and herbicides least used. The Buea farmer's herbicide use was less than that identified in Ghana [18]. This lower herbicide use may be the result of farmers able to manually weed their farms with their family members or friends using hands, cutlasses and hoes on the smaller farms.

Most Buea farmers (83.8%) anticipate pest infestations and began spraying the plants from the nursery to few weeks after transplanting. This practice shows that the farmers target any organisms that may pose as threat to the tomatoes. The problem is that natural organisms are killed which benefit the ecosystem, including earth worms which render the soil airy and ease water and other minerals absorption in the crops.

A concerning finding was that almost 95.0% of Buea farmers used indiscriminate chemical combinations with repeated application of pesticides in hope of acquiring rapid and improved results. Yet, some of these combinations have been shown to facilitate the development of pest resistance to the chemicals [9], as well as building toxic residues in plants, vegetables and fruits which could also pose a health threat to consumers. In Ghana, these practices have been found to have left insecticide residue in vegetables [16].

A knapsack sprayer (83.8%) was the main pesticide application equipment used by the famers. But, only 39.8% of farmers were able to afford a knapsack. The other farmers must depend on either renting or borrowing this equipment from friends. Those farmers having no access to sprayers (16.1%) use hand sprinkling by improvising methods of attaching brushes, mesh, leaves of plants on a wooden short stick to sprinkle their pesticides after mixing in an open container (bucket or bowl).

It is important to keep knapsack sprayers in good condition and operating properly. Sprayers have been known to spill or leak, especially when overused on rotational bases. An association has been shown between knapsack leakages and human health effects [7] [17]. Toxic residues on the skin and clothes can cause acute pesticide poisoning. All pesticide residues should be immediately removed from the skin with soap and water when spills and leaks occur. The use of hand sprinkling makes the farmers more prone to spill the pesticide with resulting skin exposure and inhalation. Many Buea farmers were not well informed on the management of pesticide spills. Improved and affordable equipment are especially needed in tropical regions of Africa where many farmers do not have adequate equipment or must use knapsack sprayer for a longer periods without maintenance or replacement.

The method of pesticide application and practices which are used by most Buea farmers exposes them not only to acute effects of pesticide poisoning but to the long term effects of neurological damage and cancer. Many of the farmers mixed and sprayed pesticides injudiciously using knapsack sprayer cups and teas spoons without accurate measurements leading to an incorrect estimation of pesticide strength and overdosing of the chemicals. Although fungicide usage is said to have little effects on humans, studies have shown that there is high risk of cancer with long term use of mancozed of the carbamate chemical group [11].

The farmer's health risks were further increased because farmers were not aware of the need to monitor wind directions when spraying and even smoked while spraying. Less than one-fourth of farmers said they used PPE (long sleeved shirts, long pants, boots or closed toed shoes, gloves, masks, and a hat), with the majority (76.4%) of farmers wearing no or partial PPE. These exposures increase the farmer's risk of pesticide poisoning and possible health effects, which could explain why 85.3% of farmers reported signs and symptoms of acute pesticide poisoning after spraying.

In the Ivory Coast, farmers avoided medical care on the assumption that signs and symptoms of pesticides poisoning are a normal phenomenon and need no medical attention [18]. This attitude further broadens the risk of long term effects of pesticides poisoning. Although most of the Buea farmers assumed their symptoms were from pesticide use, they thought that the symptoms were expected effects of pesticides use and should be accepted. Some farmers denied that these symptoms could be due to pesticide use, but attributed the symptoms to something other than pesticide exposure.

Many Buea farmers said they discarded the pesticides containers on the farm. This was confirmed at the farm visits where many empty pesticide containers could be seen in clusters as one walked in the fields. The disposal of used containers was further complicated, because most of the farms are located along streams which were easier to use to wash the sprayers and to discard the used water. Because this is a mountainous terrain, most of this water runs off and the containers are swept away by rain into the streams and rivers which empty into the Atlantic Ocean. There is a potential pollution threat to the communities along the water way and to non-targeted fauna and flora which has a potential of destabilizing the food chain and the ecosystem at large. Further studies are needed to evaluate this possibility in order to put in place adequate measures to control such practices.

The availability of potable water remains a health concern throughout Cameroon in both urban and rural areas. Although the Buea municipality does have a potable water system, most farmers use it only for drinking water and use the streams for their domestic activities in order to limit water bills. The impact of this practice upon the water sources (streams) is concerning, for both the soil and the water may be affected.

After using pesticides, the farmers do observe a decrease in pests and disease. The pesticide venders emphasize this benefit and make pesticides more financially attractive by distributing pesticides in smaller quantities of unlabelled containers. Labeling information is essential to making specific instructions for pesticide use available to all pesticide users. This practice does not encourage farmers to investigate other suitable non-chemical and environmental friendly methods that are equally inexpensive but offer good control of pests. Some of these methods include crop rotation, intercropping and even the occasional use of botanical synthetic pesticides which have been effective in some developing countries [19] [20].

The analytical ranking game showed that 28 pesticides were recognized and used by these farmers. It was reassuring that the farmers were able to rank and differentiate pesticides in accordance with WHO standards. The farmers recognized that these were hazardous chemicals and most farmers rated the pesticides as extremely hazardous as opposed to moderately hazardous. Yet, having knowledge of the hazards did not translate into behavior. Most farmers did not follow commonly recommended guidelines for safe use of pesticides, including using PPE, hand washing with soap/water after spraying, not eating in the fields, not washing of work clothes with family clothes, and proper disposal of pesticide containers. These actions subject the farmers and their households to increased pesticide exposure and risk of pesticide poisoning. There is an obvious need for these farmers to be provided further education, especially on the safe use of pesticides. In many countries, this sensitization has been successfully provided by agricultural extension service programs which have helped farmers to reduce the risks of pesticide use and to provide alternate options for pest control.

All farmers cultivated tomatoes during the dry season, with an average frequency of spraying being once a week until harvest. Those farmers, who cultivated tomatoes during the wet season, reported spraying more frequently than in the dry season. This increase in spraying frequency was a result of rainfall which washes the pesticides off the plants and increases the need for further spraying. Therefore, only a few farmers were able to cultivate tomatoes during the rainy period due to the high cost of pesticides. Seeking alternate options for pest control may assist more farmers to extend their planting seasons.

Finally, the concerning use of pesticides has the potential to threaten the health of the environment through soil, water and air pollution. A goal of this study is to promote awareness of the risks associated with pesticides usage even in small-scale farming practices. It is hoped that the policy formulators will become aware for the need of interventions to be developed which can educate and support the farming communities, the general populations, and the environment in Cameroon.

5. Study Limitations

The number of participants is statistically small with study participation limited to one geographic area of Cameroon. Although the findings were consistent with field observations, they may or may not reflect the knowledge, attitudes, and use of pesticides by farmers within the Buea municipality and other Cameroon communities.

All farmers decided for themselves if they wished to participate in the study. This raises the possibility of a "self selection" bias in the findings. Therefore, the participant's responses and practices may or may not represent typical farmers in the area.

6. Conclusions and Recommendations

This study provides valuable information concerning the trend in pesticide knowledge, attitudes, and use in a community of small-scale tomato farmers in Buea, Cameroon. The study revealed that small-scale tomato farmers lack adequate knowledge on the safe and judicious use of pesticides. Knowledge deficits included the use of PPE when applying pesticides, the proper handling and disposal of pesticides, and the possible individual, family and community health impact of pesticide use.

To increase the farmer's knowledge and promote positive farming practices, field-based agricultural training programs should be encouraged. Studies have shown that such programs are effective in transforming farmer's behaviors and actions to improve their pesticide use [16]. These education programs can address the multiple concerns surrounding pesticide use, including reducing health effects of pesticides exposure, safe handling of pesticides, reading and interpreting of labels, the importance of the use of PPE, and the proper disposal of used pesticides containers and waste water from the knapsack sprayers. Small-scale farmers depend on local pesticide vendors not only as their point of purchase, but also as their main source of information about pesticide use. These venders should also be encouraged to participate in the education training programs provided to farmers. The venders need to understand how to effectively distribute pesticides to farmers and guide them on their usage.

This study showed that further investigation should be conducted on the soil and water within this region. It is important to identify how pesticide use can be safe and effective in multiple environments, as well as to determine a baseline measurement of the present level of pesticide contamination.

Although some farmers are aware of the health risk associated with pesticides use, many do not practice adequate measures to minimize the health effects. Many farmers believe that the symptoms of acute pesticide poisoning are attributable to other causes. Pesticide exposure has the potential to be a serious public health problem within these communities. An active agricultural extension service and training program could address the sales, purchase and use of pesticides by vendors and farmers.

This study focused upon pesticide use within the Buea area; further investigations in other Cameroon communities are encouraged to enable a national strategic plan to be developed to address pest control and pesticide use.

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