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# VEGETABLE FARMERS' KNOWLEDGE AND SAFETY PRACTICES TOWARDS PESTICIDES: RESULTS FROM FIELD OBSERVATION IN SOUTHEASTERN DR CONGO

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## *ABSTRACT*

Plant protection products can cause serious health issues especially for farmers who are exposed to all steps of their use. We used field observation to assess farmers' knowledge of pesticides as well as their behavior while preparing mixtures, spraying and rinsing equipment used. Results showed that most of the farmers (97.6%) used pesticides (organophosphate and pyrethroid insecticides) and reported having both positive and negative perception of pesticides apprehended respectively in terms of benefits (improve crop quality) and hazards (source of diseases, poison for human). Farmers' knowledge of meteorological parameters and personal protective equipment for successful and safe use of pesticides was still limited. Farmers observed (98%) did not wear personal protective equipment (gloves, mask, coverall) during all steps of pesticide use (mixing, spraying, rinsing equipment). Hygienic practices were also very poor since 100% of farmers monitored could not change the clothes worn during the crop treatment. Furthermore, 88% of the farmers observed did not wash hands, feet and legs immediately after pesticide application whereas those parts of the body were particularly exposed during the treatment. This study provides reliable evidence related to the hazardous use of pesticides in Lubumbashi. A program of awareness and information will help to relieve farmers from pesticides health risks.

**Contribution/Originality:** This study is one of the very few studies which have investigated the misuse of pesticides in Lubumbashi. Results highlighted poor handling practices of pesticides by farmers and limited knowledge of protective equipment and weather conditions while using plant protection products.

## 1. INTRODUCTION

In the Democratic Republic of Congo, 16,000 small farmers are involved in urban and periurban horticulture and grow 150 000 tons of fresh vegetables per year for 11.5 million urban residents [1]. Parallel to that production, there is simultaneously a development of the informal market of agricultural inputs including synthetic pesticides. Pesticides are widely used in agricultural production to control pests, diseases, weeds in an effort to reduce yield losses and maintain high product quality [2, 3]. A recent survey conducted in Lubumbashi reported that 97.6% of vegetable famers spray pyrethroid and organophosphate insecticides because of their effectiveness and immediate action on pests [4]. Despite their perceived benefits, misuse and poor handling practices of pesticides can lead to serious health issues arising from the exposure while mixing, spraying pesticides and working in treated fields [5-8]. For many farmers, the situation has been exacerbated because of the lack of protective equipment, the use of

inappropriate spraying equipment, pesticide application during bad weather conditions ( strong winds or high temperature, low humidity) [9, 10] and the improper combination of several chemicals [11-13]. In many countries like DR Congo, sale agents who are the main source of information for farmers on pesticide choice and use [5, 14] have also limited knowledge of plant protection products and are not trained to handle safely chemicals [15]. Furthermore, the language barrier is another challenge for farmers and pesticide retailers since they cannot understand pesticide label instructions written generally in foreign languages (English, Chinese) [15]. Research conducted in Tanzania showed that pesticide distribution accompanied by unsafe practices can contribute to the burden from acute pesticide poisoning, not only affecting the distributors but also farmers who buy and use these products [16]. Farmers knowledge and safety practices have been studied in many countries like Ghana, Indonesia and Nepal where it has been proved that farmers know the importance of using personal protective equipment such as hats, masks, glasses, boots, and gloves [11, 17, 18]. However, poverty, strong heat and negligence (low perception of the risks) are cited among the factors preventing farmers to use protective equipment [19, 20]. According to Maria, *et al.* [17]; Vaidya, *et al.* [21] the possible strategy of relieving farmers from the health risks associated with pesticide exposure is to deploy a program of awareness and information. In Lubumbashi, last decade a large project of urban and periurban horticulture has promoted a couple of Integrated Pest Management techniques to minimize the use of chemical inputs by the farmers but its adoption has been low [4]. This study was initiated to assess farmers' knowledge of pesticides as well as their safety practices while spraying pesticides on vegetable crops in periurban areas of Lubumbashi, DR Congo. This research focused on the meteorological factors, the use personal protective equipment as well as the farmers 'behaviour while and after pesticide application. Information gained in this study is valuable and can be used by policy makers, agricultural extension officers as well as scientists to design a suitable program of information on safe use, storing and handling of pesticides.

## 2. MATERIAL AND METHODS

### *2.1. Study Area*

This study was conducted in the city of Lubumbashi located between 11° 27'and 11° 47' S and between 27° 19' and 27° 40' E in the southeastern Democratic Republic of Congo [22]. It is the second largest city in DR Congo and one of the fastest growing African cities with annual population growth rate of 5% [23]. The Department of Economic and Social Affairs of United Nations [24] estimated 2 097 000 habitants in Lubumbashi. Human pressure and competition on resources (land, forest) have been reported [23, 25]. Periurban agriculture is an important activity for many poor dwellers in that city where the rate of unemployment is important [26, 27]. Between 2002 and 2010, the area dedicated to urban and periurban agriculture has passed from 100 up to 725 hectares and that situation has led to the creation of several production sites [1]. The vegetable production sites investigated were Kimilolo (11° 43'007 " S , 27 ° 25'66"E) ; Kilobelobe ( 11 ° 40'306 " S, 27 ° 30'974 " E) , Maendeleo( 11° 42'615 " S, 27 ° 27'976 " E), Naviundu (11 ° 37 '825' S, 27 ° 31'266 " E) and Tingi-Tingi ( 11° 36'540 " S, 27 ° 28'433 "E).The study area benefit of humid subtropical climate (Cw type of the Köppen classification system with one rainy season (November-March) and one dry season (May-September), separated by October and April as transitional months [22]. The mean annual temperature is 20 °C; the warmest month is October (23 °C) and the coolest is July with 15.6 °C [28].

### *2.2. Data Collection*

To assess farmers' knowledge and safety practices towards pesticides, data were collected in two rounds. First, 246 vegetable farmers were randomly interviewed using a questionnaire. Data collected at the first round were relative to the gender, education, land access, farm sizes, training, and perception of pesticide, use pattern, re-entry and pre-harvest periods). Secondly, from March to June 2017, a random sample of 50 vegetable farmers was drawn from the list of 246 vegetable farmers previously interviewed. Selected farmers were monitored in order to obtain

comprehensive information on their attitudes and safety practices while mixing, spraying and after working. Field observations are important while monitoring farmers' practices and use of protective equipment [3, 29]. In addition, observations help to understand farmers' knowledge, attitudes and their safety practices. [11, 18, 30]. To assess hygienic practices, we observed whether farmers washed hands and feet, changed the clothes worn during spraying or took bath immediately after pesticide application [31]. We focused also on negligent behavior like eating and smoking during the application as well as the presence of people without personal protection equipment around the treated farms.

### *2.3. Data Analysis*

Data analysis was performed using frequencies and percentages for the variables examined. The means and standard deviations were also calculated (farmer's age and farming experience). The Chi-square test ($\chi$2-test) was used to investigate the significant associations or difference between farmers' profile (Gender, age, experience in farming, land size, training) and pesticide use practices. The criterion for statistical significance used in this study was $\alpha < 0.05$.

## 3. RESULTS

### *3.1. Farmers' Socioeconomic Characteristics*

The socioeconomic characteristics of the sample of farmers are given in Table 1. More than half (52%) of vegetable farmers were young male who were considering the vegetable production as part of their employment. The average age of the respondents was 40±12 years with an experience of 9 years in vegetable production. A large part of farmers (63%) attended high school and cultivated small plots of 3.6 ares to grow vegetables (Chinese cabbage, amaranth). Almost of the farmers(97.6%) used insecticides to control pests.

**Table-1.** Vegetable farmers' socioeconomic characteristics( n=246).

| Variables | Category | Number of farmers | Percentage (%) | Mean ±SD |
|---|---|---|---|---|
| Gender% | Male | 128 | 52 | --- |
| | Female | 118 | 48 | --- |
| Age (years) | | 246 | --- | 40±12 |
| Education | Primary | 54 | 21 | --- |
| | High school | 155 | 63 | --- |
| | University | 34 | 14 | --- |
| Farmer's experience(years) | | 246 | --- | 9±7 |
| Farms' size (ares) | | 246 | --- | 3.6±2.4 |
| Pesticide use (yes)% | | 240 | 97.6 | ---- |

**Note:** SD represents Standard deviation.

### *3.2. Pesticide Use Pattern and Farmers' Perceptions*

Results indicated that a good part of famers mixed two insecticides in belief that the effect will be great. However, the chi-square test did not show significant association between farmers (female and male) regarding the use pattern of pesticides ($p > 0.05$) as reported in Table 2. Most of the farmers (72.2%) used only one pesticide whereas 22.8% combined two different products. In fact, farmers had both positive and negative perception of pesticides that can be apprehended in terms of the benefits and hazards Table 3.

**Table-2**. Gender and use pattern of pesticides.

| Gender | Use only one | | Mixing two pesticides | | p-value |
|---|---|---|---|---|---|
| | Frequency | Percentage | Frequency | Percentage | |
| Male | 96 | 75.0 | 32 | 25.0 | 0.384 ns |
| Female | 94 | 79.7 | 24 | 20.3 | |
| Total | 190 | 72.2 | 56 | 22.8 | |

**Note:** ns means no significant.

**Table-3.** Farmer's perception of synthetic pesticides.

| Gender | Positive perceptions | | | | Negative perceptions | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Effective to control pests | | Improve crop quality | | Destroy non target | | Source of diseases | | Poison | | Don't know | |
| | n* | % | n | % | n | % | n | % | n | % | n | % |
| Female | 114 | 96.6 | 105 | 89.0 | 6 | 5.1 | 38 | 32.2 | 65 | 55.1 | 9 | 7.6 |
| Male | 124 | 97.0 | 116 | 90.6 | 4 | 3.0 | 46 | 36.0 | 74 | 58.7 | 4 | 3.1 |
| p-value | 0.407 ns | | | | 0.352 ns | | | | | | | |

**Note:** *: Number of farmers, ns: no significant.
**Source:** Survey, 2016.

### *3.3. Farmers' Knowledge of Critical Stage of Pesticides Use*

Farmers were asked to indicate the most dangerous step during pesticide application process. Result show that there were no significant differences (p>0.05) between farmers' profile and the three steps of using pesticide including the preparation of mixture, spraying and rinsing the equipment used Table 4.

**Table-4.** Farmers' profile and knowledge of critical step while handling pesticide.

| Variables | | All stages | | Mixture | | Spraying | | Rinsing | | P-value |
|---|---|---|---|---|---|---|---|---|---|---|
| | | n* | % | n | % | n | % | n | % | |
| Gender | Male | 8 | 27.6 | 7 | 24.1 | 14 | 48.3 | 0 | 0.0 | |
| | Female | 4 | 19.0 | 4 | 19.0 | 13 | 61.9 | 0 | 0.0 | 0.627ns |
| Age (years) | 17-30 | 5 | 29.4 | 2 | 11.8 | 10 | 58.8 | 0 | 0.0 | |
| | 31-49 | 5 | 22.7 | 7 | 31.8 | 10 | 45.5 | 0 | 0.0 | 0.595 ns |
| | >50 | 2 | 18.2 | 2 | 18.2 | 7 | 63.6 | 0 | 0.0 | |
| Experience (years) | 1-5 | 11 | 32.4 | 8 | 23.5 | 15 | 44.1 | 0 | 0.0 | |
| | 6-10 | 1 | 12.5 | 1 | 12.5 | 6 | 75.0 | 0 | 0.0 | 0.461ns |
| | 11-19 | 0 | 0.0 | 1 | 25.0 | 3 | 75.0 | 0 | 0.0 | |
| | >20 | 0 | 0.0 | 1 | 25.0 | 3 | 75.0 | 0 | 0.0 | |
| Training | Yes | 3 | 15.8 | 4 | 21.1 | 12 | 63.2 | 0 | 0.0 | |
| | No | 9 | 29.0 | 7 | 22.6 | 15 | 48.4 | 0 | 0.0 | 0.□09ns |

**Note:** *n= number of farmers, ns: no significant.
**Source:** Survey, 2017.

A good part among respondent male (48.3%) and female (61.9%), young (58.8%) and aged farmers (63.6%) either those who attended previously farming trainings (63.2%), all attested that pesticides were more risky and hazardous while spraying. Few among male (24.1%) as well as female (19%) knew that the most dangerous operation was the preparation of the mixture because the product handled is still concentrated and can be more hazardous. None among farmers knew that while rinsing the equipment (knapsack sprayers, buckets) the risk of contamination was still important. The Figure 1 illustrates the way farmers handle chemical pesticides when they estimate the dose and prepare the mixtures.

**Figure-1.** Photos illustrating unsafe practices among farmers during dose determination (left) and mixing (right) without protective equipment, site Kimilolo, Lubumbashi May, 2017.
**Source:** Field observation, 2017.

### *3.4. Farmers' Knowledge of Personal Protective Equipment (PPE)*

The informations about farmers' knowledge of personal protective equipment are presented in Table 5. The majority of farmers (62%) cited long clothes (pants and shirt long sleeve) and hate as the necessary PPE during pesticide application and 30% mentioned mask and gloves. Only few of farmers (10%) have good knowledge of the complete PPE (mask, gloves, hate, coverall, boots and glasses). However, 22% of farmers did not know any protective equipment and reported not paying attention on PPE.

**Table-5**. Farmers' knowledge of personal protective equipment.

| Protective Equipment | Frequency | Percentage (%) |
|---|---|---|
| Mask and gloves | 15 | 30 |
| Coverall and gloves | 7 | 14 |
| Gloves and boots | 4 | 8 |
| Glasses and gloves | 4 | 8 |
| Long clothes and hate | 31 | 62 |
| All PPE | 5 | 10 |
| Do not know | 11 | 22 |

**Source:** Field observation, 2017.

### *3.5. Assessment of Farmers' Safety Practices*

Safe practices during pesticide application are important to minimize farmers' vulnerability to pesticides. However, only 2% of vegetable farmers observed put on gloves, masks, glasses and coverall while preparing mixture and spraying pesticides. More than half of farmers (54%) put on long clothes (pant and shirt with long sleeves) during mixture and 70% while spraying and rinsing the material used Table 6.

**Table-6.** Personal protective equipment used while using pesticides.

| Operations | Personal protective equipment | | | | | | |
|---|---|---|---|---|---|---|---|
| | Gloves n* (%) | Masks n (%) | Boots n (%) | Coverall N (%) | Hate n (%) | Glasses n (%) | Long clothes n (%) |
| Mixture | 1(2) | 1(2) | 11(22) | 1(2) | 4(8) | 1(2) | 27(54) |
| Spraying | 1(2) | 1(2) | 11(22) | 1(2) | 4(8) | 1(2) | 35(70) |
| Rinsing | 0(0) | 0(0) | 11(22) | 1(2) | 4(8) | 0(0) | 35(70) |

**Note:** *number of farmers.
**Source:** Field observation, 2017.

### *3.6. Farmers' Knowledge of Meteorological Parameters*

The weather conditions observed by farmers before spraying pesticide on vegetable crops are shown in Table 7. Results reveal that only 40% of farmers could not spray during windy or rainy time or when the temperature was high. A high portion of farmers (30%) did not know any meteorological factor.

**Table-7**. Meteorological parameters observed by farmers before applying pesticide.

| Parameters | Frequency | Percentage (%) |
|---|---|---|
| None | 15 | 30 |
| Temperature and sunlight | 8 | 16 |
| Wind and rain | 5 | 10 |
| Wind only | 17 | 34 |
| Rain only | 5 | 10 |
| All parameters | 20 | 40 |

**Source:** Survey, 2017.

### *3.7. Farmers' Attitudes during and after Applying Pesticides*

All Farmers observed have demonstrated some inappropriate and unsafe practices either during or after pesticide use Table 8.

**Table-8.** Farmers' attitudes during and after applying pesticides.

| Observations (n=50) | Frequency | Percentage |
|---|---|---|
| Applicator does not change clothes after pesticide application | 50 | 100.0 |
| Applicator does not wash hands and feet | 44 | 88.0 |
| Applicator smokes while spraying | 1 | 2.0 |
| People are around the field being sprayed | 45 | 90.0 |
| Applicator keeps working in the treated field | 28 | 56.0 |
| Applicator is being assisted by a fellow without PPE | 16 | 32.0 |
| Applicator fixes sprayer full of mixture while spraying | 3 | 6.0 |
| Applicator rinses the spraying material in the water point | 6 | 12.0 |
| Applicator leaves the empty pesticide containers on field | 43 | 86.4 |

**Source:** Field observation, 2017.

All farmers observed (100%) did not change the clothes worn during pesticide application and 88% did not wash their hands and legs just after spraying. Two (2%) were smoking while spraying and surprisingly 56% kept working and walking in the treated field. Most of the farmers (90%) sprayed pesticides while people (family members, fellow famers) were around the farms and some of them could be asked to assist the applicator (32%) to lift, load knapsack sprayers or provide any assistance. After spraying, 12% applicators were rinsing equipment (knapsack sprayers, bucket) in any water point or river closer to the farms whereby generally harvested vegetables were also washed before they were taken to the local markets. We noticed that 86.4% of farmers left empty containers of pesticide in their fields.

### *3.8. Re-Entry Interval Observed by Vegetable Farmers*

The re-entry interval is shown in Table 9. Results show that a high proportion of farmers interrogated (65%) returned back to work in their farms 24 hours (next day) after spraying ,8% reentered in earlier( less than 24 hours) whereas 5% of farmers observed 72 hours.

**Table-9.** Re-entry interval.

| < 24 hours | | 24 hours | | 48 hours | | 72 hours | |
|---|---|---|---|---|---|---|---|
| n | % | n | % | n | % | n | % |
| **20** | 8 | 161 | 65 | 53 | 22 | 12 | 5 |

**Note:** n represents number of farmers.

### *3.9. Pre-Harvest Interval Observed by Farmers*

The Figure 2 presents the pre-harvest period observed by the sample of vegetable farmers.

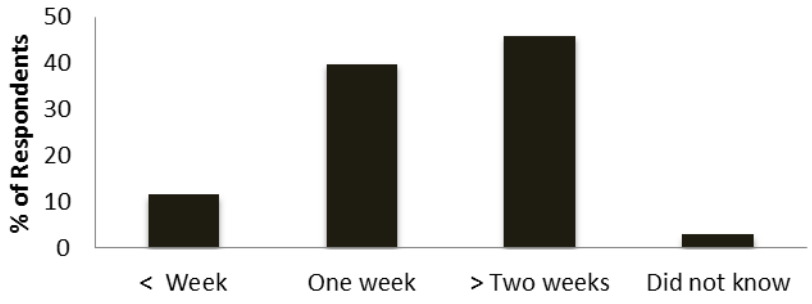


**Figure-2.** Pre-harvesting interval observed by vegetable farmers (n=246).
**Source:** Survey, 2016.

A higher proportion of farmers (49.9%) harvested over two weeks after the last pesticide application while more than 11% harvested less than 7 days after the last spray. Results also show that 2.8% did not pay attention on the pre-harvest interval even if they had applied pesticides.

## 4. DISCUSSION

This study assessed farmers' knowledge as well as their safety practices while applying pesticides to control pest in vegetable crops in Lubumbashi. Understanding the actual farmers perception, attitudes and their safety practices can help to deploy or to re-enforce the program of awareness to relieve farmers from pesticide hazards [17, 21].

### *4.1. Farmers' Perception of Pesticides*

Vegetable farmers (97.6%) in Lubumbashi used pesticides, especially insecticides because they helped to control pests and improved vegetable quality. That point of view is consistent with many studies conducted in many countries stating that pesticides boost crop productivity and reduce yield losses [2, 3, 6, 18, 19, 32]. Inspite of the perceived benefits, farmers had also a negative perception of pesticides. A good part among farmers considered respectively the pesticides as a poison (58.7%) and source of deseases for human (36%). That farmers 'concern is likely normal and true because pesticide applicators in many countries reported self-poisoning and discomfort cases (headache, skin itching, fatigue and cancer) after a short or long period of using pesticides [5, 11, 12, 14]. Few farmers mentioned that pesticides destroy also non target insects such as bees. Bommarco, et al. [33] highlighted also the loss of beneficial natural enemies of crops after spraying insecticides.

### *4.2. Farmers' Knowledge and Pesticide Handling Practices*

Farmers attested that pesticides were more risky and dangerous during spraying. This situation can be explained by the fact that using poor spraying equipment such as buckets and brooms, farmers got contaminated with the pesticides during application [15]. However, many farmers were still ignoring the danger of pesticide while measuring the dose and preparing mixtures Figure 1. Concentrated product is more hazardous but also toxic. The preparation of mixtures is a critical operation for pesticide applicators [7, 13]. This step requires more attention and caution in term of safety (personal protective equipment: gloves are a mandatory). Unfortunately, farmers observed were likely minimizing the hazard at this step and did not take appropriate safety measures. The same situation has been observed in Cote d'Ivoire**,** Togo and Burkina Faso where Ajayi and Akinnifesi [19]; Kanda, et al. [20]; Son, et al. [34] observed respectively that 53% , 87% and 70% of pesticide applicators did not wear any protective equipment from the preparation of the mixture until the end of the treatments. Using complete personal protective equipment (mask, gloves and protective clothing) is encouraged because it helps farmers reduce the risk of exposure to pesticide more than 800 times [34]. Farmers do not use personal protective equipment (PPE) in countries for different raisons: high cost of protective equipment, poverty, high temperature (make farmers uncomfortable), luck of information on PPE, low perception of the risks [13, 19, 20].

### *4.3. Attitudes and Hygienic Practices*

Farmers demonstrated unsafe and poor hygienic practices after spraying the pesticides. All farmers (100%) did not change the clothes and 88% did not wash their hands and feet, mostly contaminated just after spraying. Hands and feet as well as legs are the most exposed to pesticide deposition from mixing, handling contaminated objects, spraying and walking in treated crops [29, 35, 36]. Poor hygienic practices have been reported also among farmers in Burkina Faso where 43% of farmers did not wash their hands after pesticide application [31]. A study conducted in Iran by Seyyed, et al. [37] indicates that most of the farmers do not follow basic pesticide safety measures because they have the lowest perceived risk and believe that the pesticides are not so much dangerous. After spraying, 12% applicators rinsed the material used in flowing river closer to the farm. The same behavior has been observed among farmers in Côte d'Ivoire where pesticide applicators washed their equipment and took bath in rivers near their fields [19]. That practice can lead to the water contamination and affect aquatic biodiversity. In

Lubumbashi the situation seems likely to be critical since the same rivers and water points help wash harvested vegetables before being taken to the city markets.

### *4.4. Re-Entry Period Observed by Vegetable Farmers*

The re-entry interval has been short for a high portion (8%) of farmers regarding to the label instructions of pesticide (diclorvos) that states the re-entry interval (REI) to 1 day. Farmers reentered in their fields earlier to water the crops because the amaranths and cruciferous vegetables grown during the dry season require more water as well as maintenance. However, the REI claimed by farmers was not consistent with our observation. For example, 56% applicators kept working in the treated field. Our findings are also different from those obtained in Ghana where 73.3% of farmers returned to their farm within 48 hours after spraying pesticides [11]. The re-entry interval is not always a safe moment for farm workers. Ngowi, et al. [5]; Aktar, et al. [6]; Toumi, et al. [8] revealed that humans come into contact with pesticides during preparing mixtures, spraying and working in a treated field.

### *4.5. Management of Empty Containers of Pesticides*

Observation carried out indicated that over 86% of farmers abandoned the empty containers of pesticides in open field. This practice is not good and has been widely reported in many developing countries Kanda, et al. [20]; Son, et al. [34]; Gouda, et al. [38]. A survey conducted in Togo by Kanda, et al. [20] reported that the ignorance of the danger of empty containers has led farmers to poor disposal and management. We observed also that leaving empty containers is dangerous since those containers are collected by children to set up their games and or collected for other domestic use (Keeping drinks). The current disposing techniques stand for a triple rinsing with water of empty containers to reduce systematically pesticide residues. Empty containers are to return back to the manufacturer or recycling agent [39]. However, the challenge in many developing countries like DR Congo is that farmers obtain pesticides in different ways including informal market, donation or exchange between fellow farmers.

## 5. CONCLUSION

This study provides valuable information on farmers' knowledge of pesticides and reports poor safety practices while preparing mixtures, spraying and rinsing equipment. Findings show that a good part of vegetable farmers is aware of pesticides hazards and consider them as a poison and source of diseases for human. Most of farmers are still ignoring that the preparation of mixture requires more caution in term of safety because the product handled is still concentrated and toxic. Farmers' knowledge of personal protective equipment, hygienic practices and weather conditions is still limited and this has led farmers to unsafe practices either during or after pesticide application. The re-entry interval is short compared to that reported in West Africa but the good news is that the pre-harvest interval claimed by a high part of famers meets the label instructions of two of the main insecticides (Lambda-cyhalothrin and Diclorvos) mostly used in Lubumbashi. Since farmers' health and the protection of the environment should be an important concern for policymakers, the results from this study can hopefully help to design a suitable program of awareness and information for farmers.

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