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Knowledge and Practices of Pesticides Used against the Bean Fly (O*phiomyia phaseoli*) and Associated Health Effects among Bean (*Phaseolus vulgaris*) Smallholder Farmers in Kabaru Location, Nyeri County

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Abstract

Farmers' knowledge and practices regarding pesticides used against the bean fly, (*Ophiomyia phaseoli*) and the associated health effects is of great public health importance. This information is lacking among smallholder bean farmers in many sub-Saharan countries. A structured questionnaire was administered to 385 study participants. Systematic random sampling using a point transect method was performed and both qualitative and quantitative methods were used. A Likert Scale was used to scale responses. Data were analyzed using SPSS software. Differences between response categories were determined using the Chi-square test. The pesticides used in this study belonged to the pyrethroids (55%), organophosphates (18%), neonicotinoids (18%), and carbamate (9%) chemical families all of which belong to the WHO class II. Data from the Likert Scale on knowledge of pesticides showed that 96% scored above15 out of highest score of 20. Similarly on practices, 76% scored above 12 out of the highest score 15. The major self-reported clinical effects following pesticide use were headache, backache, dizziness, eye problems and sneezing. Although the farmers had a reasonable knowledge of the hazards of pesticides, they utilized undesirable practices such as incomplete use of Personal Protective Equipment (PPE). Therefore, more training is recommended to promote pesticide knowledge and safer practices for all the farmers.

Keywords: Organophosphates, pyrethroids, neonicotinoids, toxicity, self-reported data.

Introduction

Agriculture is the leading user of pesticides followed by vector control (Karunamoorthi, Mohammed, & Jemal, 2011). Over the past years there has been an increase in the use of pesticides in developing countries (Oesterlund et al., 2014). According to the World Health Organization, (WHO, 2011), the level of safe pesticide management in developing countries is low.

Insect pests such as the bean fly, *Ophiomyia spp*. (Diptera: Agromyzidae), are the most important field and storage pests, respectively (Abate, 1991) which can cause up to 100% loss (Ochilo & Nyamasyo, 2011; Wickramasinghe & Fernando, 1962). The management of bean fly is difficult because of the cryptic behavior of the pest. Most farmers do not believe that they can successfully cultivate the bean crop without using pesticides. Farmers get less profits and low field harvests because of bean fly damage which results in the great risk of failing to contribute as expected towards the GDP and achievement of Millennium Development Goal (MDG) number one which is to eradicate extreme hunger and poverty.

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Organophosphates, carbamates, organochlorines and pyrethroids are potentially hazardous pesticides that are widely used in various parts of East Africa (Mbakaya et al., 1994; Ohayo-Mitoko, Kromhout, Simwa, Boleij, & Heederik, 2000). Most commercial pesticides are very effective but are not eco-friendly to natural enemies, to human and wildlife safety, and have raised severe global environmental concerns (Prakash, Rao, & Nandagopal, 2008).
The Food and Agriculture Organization, (FAO, 2006) has highlighted the importance of rules for the proper storage of pesticides in order to maintain product efficacy and to prevent contamination of the surroundings. The WHO classification of pesticide toxicity has been used by regulators to help determine which pesticides should be restricted (WHO, 2010). According to WHO (2010), poor capacity to enforce regulations leads to the excessive and unsafe use of pesticides, which can result in the contamination of food, drinking water and the environment, as well as affecting birds and aquatic organisms.

Studies in developing countries indicate that farmers usually source pesticide information from pesticide vendors and from other farmers (Sodavy, Sitha, Nugent, & Murphy, 2000) who are not knowledgeable about pesticide risks. The knowledge and practices of pesticides used against insect pests and the adverse effects of pesticides on human health and the environment are of great importance (Yalemtsehay Mekonnen & Tadesse Agonafir, 2002b; Nalwanga & Ssempebwa, 2011; AV Ngowi, Maeda, & Partanen, 2001; A. V. Ngowi et al., 2001). The practices include the pest control measures used, the protective gear, the storage of pesticides prior to use and the fate of empty pesticide containers (A. V. Ngowi et al., 2001; Ntow, Gijzen, Kelderman, & Drechsel, 2006). The WHO (2010) has reported that storage of pesticides by small-scale farmers is still a major challenge in many developing countries.

The frequent exposure to pesticides results in both short-term (acute) and long-term (chronic) illnesses (Asfaw, 2008; Maumbe & Swinton, 2003). Self-reported signs and symptoms following pesticide use include headache, sneezing, vomiting, stomach ache, backache, dizziness, skin rash and eye problems (Lekei, Ngowi, & London, 2014; Ohayo-Mitoko et al., 2000). Other documented health effects include eye irritation, seizures, respiratory problems, neurological damage, birth defects (Farquhar et al., 2009) coma, cancer and death (Antle & Pingali, 1994; Harris, Renfrew, & Woolridge, 2001; Macharia, Mithöfer, & Waibel, 2009).

The risk for and severity of adverse health effects from pesticide exposure varies significantly depending on many factors, including individual characteristics such as age and health status, the specific pesticide, and exposure circumstances (Farquhar et al., 2009; WHO, 1990). Other impacts expected due to pesticide use include:- seeking medical treatment after experiencing the earlier outlined harmful effects due to pesticide use, reduction in labour and the potential for poisoning (Crissman, Cole, & Carpio, 1994; Dung & Dung, 1999; AVF Ngowi, Maeda, & Kissio, 1992). The significance of this study is to understand the magnitude of self-reported effects of continued use of pesticides, reduce common bean losses, increase farmer income and improve research and education capabilities. This type of research will also help participants, project planners and funding agencies in their future decisions.

Materials and Methods

Study site

The survey was conducted among bean smallholder farms at Kabaru location (0.2833°S, 37.1667°E, 2309 m.a.s.l.) in Nyeri County. The major crops grown in the study area include maize, beans, Irish potatoes and vegetables (snow peas, French beans, cabbage carrots, onions, tomatoes) whereas the major cash crops are coffee, tea, horticulture and cut flowers. The average farm size is 1.75 ha. Out of the four Sub-locations, farmers from Kimahuri and Ndathi were selected to participate in the study. The farmers that were interviewed had used pesticides intensively.

Ethical considerations

Ethical considerations were taken into account. Approval to conduct the study was obtained from the KNH-UoN Ethics Research committee (ERC) (Ref no. P752/10/2016) for ethical and research approval. Written consent was obtained from all the participants prior to the study.

Target population

Kabaru location has an estimated population size of 14580 people according to Central Bureau of statistics (Central Bureau of Statistics, 1979). It has four Sub-locations namely Ndathi, Kimahuri, Kairi and Mbiriri Sub-locations which are composed of thirteen villages. This study targeted only Ndathi and Kimahuri Sub-locations with a total of seven villages.

Study population (participants)

The study population comprised of bean smallholder farmers who use the pesticides against the bean fly on their farms in Kabaru Location, Nyeri County in Kenya.

Sample size determination

Using the Cochran formula, (Cochran, 1963), $n= [z^2_{\alpha/2}\, p\ (1\text{-}p)]/\delta^2$ the sample size (n) was determined, Where n was the required minimum sample size, $Z_{\alpha/2}$ was a standard score corresponding to 95% confidence level is 1.96, P was assumed equal to 50% which is the maximum variability in proportion of the bean fly infestation which is 50/100=0.5 and 1-p is 0.5 and δ is the margin of error, 5% (0.05).
$n= (1.96 \times 1.96 \times (1\text{-}0.5) \times 0.5)/0.05 \times 0.05$
n= 385

Sampling technique

A list containing the number of households in each of the two Sub-locations and their names was made. A systematic sampling method was used in which sample members from a larger population were selected according to a random starting point and a fixed periodic interval in both Kimahuri and Ndathi Sub-locations. The sampling interval was calculated by dividing the population size by the desired sample size point readings taken at random locations along a tape that is extended to create a transect across the place. Plumb-bobs were used to ensure a vertical reading of the point through the tape. A structured questionnaire was then administered to randomly selected study participants in the two Sub-locations.

A pre-test of the questionnaire was conducted on a sample of selected bean smallholder farmers. The results of the pre-test were reviewed to ensure that the local language used was appropriate and that there was no loss of meaning. Discrepancies in interpretations or word usage were discussed by the researchers and resolved before any interviews were conducted.

Data collection

Both qualitative and quantitative methods of data collection were used in the study. A structured questionnaire was administered to the randomly selected participants in the selected Sub-locations. The questionnaire addressed the knowledge they have on pesticides used against the bean fly, the practices related to pesticides used against the bean fly, the self-reported clinical effects following pesticide use, the signs and symptoms and ways of managing them among common bean smallholders. The questionnaire was prepared in English and translated into the native local language in the location to make it easy to understand and to administer for interviewer and interviewee. Local interviewers were trained in questionnaire administration and were closely supervised during the survey. The questionnaire sought to ascertain details about the socio-demographic characteristics of the participants, level of education and farming methods. A focus group discussion (FGD) guide was also prepared consisting of specific questions that were used to gather as much information as possible targeting one group (5-12 people) in each of the two Sub-locations. One group discussion targeted the agricultural extension officers and the other group targeted the health officers in the nearby health facility. This included the key thematic areas of the study.

Measures and Analysis

For each of the surveyed members, various measures were created in order to assess their knowledge and practices regarding pesticides used to control the bean fly. This involved the importance of pesticides for pest control, the adverse impacts of pesticides on human health and the environment, the appropriate use of PPE, reading of pesticide labels, storage of pesticides prior to use, frequency of pesticide application, bathing/ hand washing, types of pesticide applicator, and the disposal of empty pesticide containers. Respondents were offered a choice of five pre-coded responses with the neutral point being neither agree nor disagree using a Likert Scale to allow the individual to express how much they agreed or disagreed with a particular statement. These responses were then scored quantitatively, the highest score being five and lowest being one for each variable. Participants whose questionnaire responses indicated a good understanding of the pesticide names, the importance of pesticide for pest control, the proper use of knapsack sprayers, the use of PPE, who read and understood pesticide labels, who safely disposed empty pesticide containers, who understood the adverse effects of pesticides on health and environment and had received pesticide use training in the past were considered to have "good knowledge" of safe pesticide use. Respondents who scored above 75% were considered to have good pesticide knowledge.

Quantitative and qualitative data analysis

Descriptive analysis was used in the study. Quantitative data were summarized as contingency tables or graphs using SPSS software. Differences between response categories within the Sub-location as well as the overall sample were determined using the Chi-square test. Focus Group Discussions data were analyzed qualitatively. Findings that differed in the FGDs data were noted in the results section. Upon completing quantitative and qualitative analysis, the results were compared thematically. All the statistical tests were performed using 95% CI as the level of significance.

Results

Socio-demographic characteristics of the respondents

The demographic features of the 385 participants of the 2 Sub-locations; Kimahuri (165) and Ndathi (220) are given in Table 1. The majority of the respondents were male (74%) and active farmers aged between 26 and 58 years. More than half of the participants had completed secondary education (52%) while 38% had completed primary education. Most (90%) of the respondents had crop production and livestock as their only sources of income.

Table 1: Socio-economic characteristics of the respondents in Kabaru location

Variables	Kimahuri Sub-location (n=165)	Ndathi Sub-location (n=220)	Overall (n=385)
	N (frequency (%))	N (frequency (%))	N (frequency (%))
Age			
15-25	7 (4.5%)	8 (3.6%)	15 (4.0%)
26-36	15 (9.1%)	94 (42.9%)	109 (28.0%)
37-47	68 (40.9%)	47 (21.4%)	115 (30.0%)
48-58	52 (31.8%)	55 (25.0%)	107 (28.0%)
59-69	23 (13.6%)	16 (7.1%)	39 (10.0%)
Gender			
Male	143 (86.4%)	142 (64.3%)	285 (74.0%)
Female	22 (13.6%)	78 (35.7%)	100 (26.0%)
Occupation			
Farming	158 (95.5%)	196 (89.3%)	354 (92.0%)
Farming and business	7 (4.5%)	24 (10.7%)	31 (8.0%)
Highest level of education			
Primary	30 (18.2%)	117 (53.6%)	147 (38.0%)
Secondary	113 (68.2%)	87 (39.3%)	200 (52.0%)
College	15 (9.1%)	16 (7.1%)	31 (8.0%)
Polytechnics	7 (4.5%)	0 (0.0%)	7 (2.0%)
Sources of income			
Crop production	0 (0.0%)	8 (3.6%)	8 (2%)
Crop production and livestock	158 (95.5%)	189 (85.7%)	347 (90.0%)
Crop production, livestock and business	7 (4.5%)	23 (10.7%)	30 (8.0%)

*N refers to the total number of sample in the location

Knowledge

The pesticides used to control bean fly in this study were from the organophosphates (18%), pyrethroids (55%), neonicotinoids (18%), and carbamate (9%) chemical families (Table 2). All the pesticides used belonged to WHO class II which are moderately hazardous chemicals.

Table 2: Commonly used pesticides to control bean fly in Kabaru location

Pesticides used	Chemical family	WHO class	Active ingredient	Total (n=385) *N (%)
Dimethoate	Organophosphate	Class II	Dimethoate	25(6.5)
Karate	Pyrethroid	Class II	Lambda cyhalothrin	83(21.6)
Actara	Neonicotinoids	Class II	Thiamethoxam	102(26.5)
Diazinon	organophosphate	Class II	Diazinon	9(2.3)
Bulldock	Pyrethroid	Class II	Beta cyfluthrin	17(4.4)
Confidor	Neonicotinoids	Class II	Imidacloprid	2(0.5)
Pestox	Pyrethroid	Class II	Cypermethrin	48(12.5)
Brigade	Pyrethroid	Class II	Bifenthrin	9(2.3)
Cyclone	Pyrethroid	Class II	Paraquat-dichloride	25(6.5)
Pirimor	Carbamate	Class II	Pirimicarb	48(12.5)
Decis	Pyrethroid	Class II	Deltamethrin	17(4.4)

*N refers to the total number of sample in the location

The Likert Scale data on knowledge of pesticides showed that 96% scored 15 and above and only 4% scored <15 out of the highest level attainable score which is 20 for the four questions each carrying five marks (Figure 1).

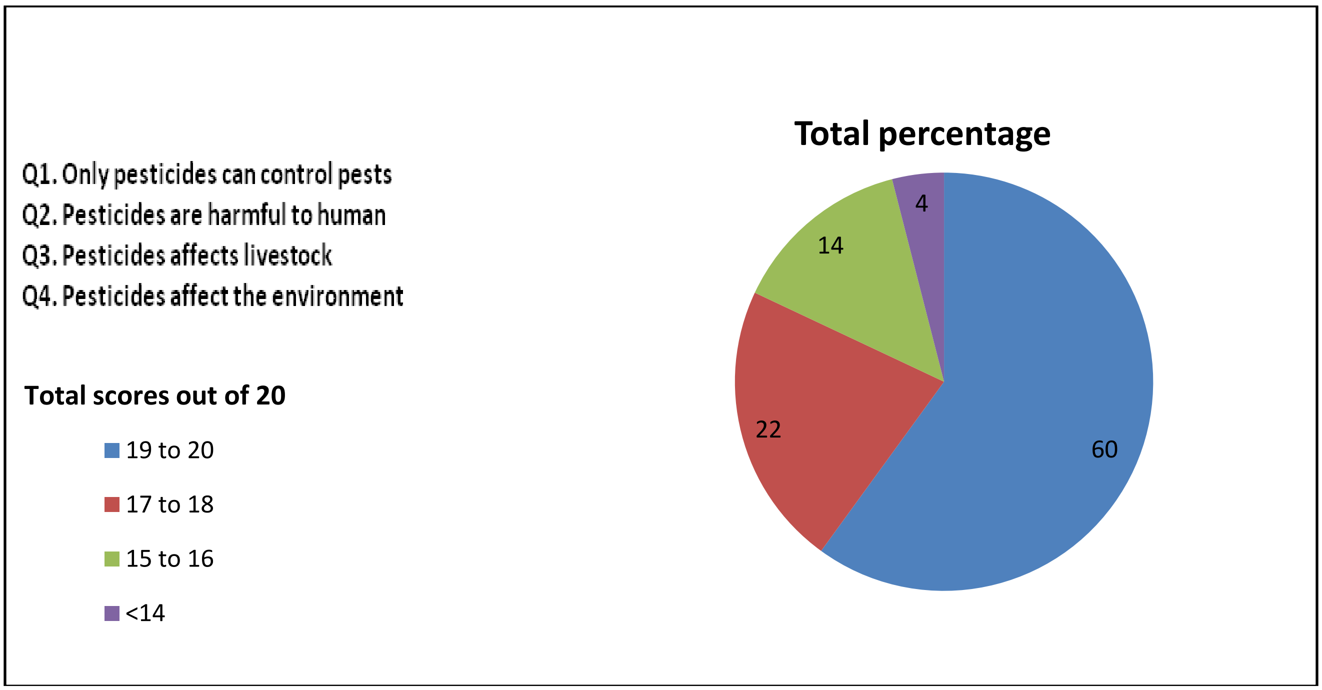

Figure 1: Responses on level of knowledge on pesticides used against the bean fly in Kabaru location according to Likert scale

Practices

The Likert Scale data on practices showed that 76% scored 12 and above while 24% scored <12 out of the highest level attainable score which is 15 for the three questions each carrying five marks (Figure 2). Ninety percent of the respondents used chemicals as the commonly used pest control measure and sprayed in the morning (Table 4). All the surveyed farmers used personal protective equipment (PPE) to prevent pesticide exposure to the skin and inhalation and most of them read the pesticide labels (Table 3). Ninety two percent of the farmers surveyed knew that pesticide containers have signs marking their toxicity levels but 60% did not know the signs marking the most dangerous pesticide. All the farmers did not eat or drink while handling chemicals. Also of concern was the poor storage of the pesticides, as shown by the variation in storage facilities. Seventy two percent stored their pesticides in their store and small number in the group store. Moreover, majority of them (90%) had pesticide training in the past.

Table 3: Pesticide safe practices and caution before use in Kabaru Location

Variables	Kimahuri Sub-location (n=165)	Ndathi Sub-location (n=220)	Total (n=385)
	Frequency (%)	Frequency (%)	Frequency (%)
Use Personal protective equipment (PPE)			
Yes	100.0a	100.0a	100.0a
No	0.0b	0.0b	0.0b
p –value			<0.00001
Read pesticide labels			
Yes	95.5a	96.2a	95.8a
No	4.5b	3.8b	4.2b
$\chi 2(1)$			0.0925
p –value			0.9548
Pesticide containers have signs marking their toxicity			
Yes	99.4a	89.0a	94.0a
No	0.6b	11.0b	6.0b
$\chi 2$ (1)			16.483
p –value			0.00026
Signs marking the most dangerous pesticide			
I don't know	59.1a	59.8a	59.5a
Red colour	40.9b	40.2b	40.5b
$\chi 2$ (1)			0.0144
p –value			0.9928
Pesticide training in the past			
Yes	90.9a	89.5a	90.1a
No	9.1b	10.5b	9.9b
$\chi 2$ (1)			0.1971
p-value			0.9062

a & b denotes that there is a significant difference between the variables

Table 4: Practices of bean smallholder farmers on pesticide use in Kabaru Location

Variables	Kimahuri Sub-location (n=165)	Ndathi Sub-location (n=220)	Total (n=385)
	Frequency (%)	Frequency (%)	Frequency (%)
Commonly used pest control measures			
Chemical	90.9a	89.3a	90.0a
Cultural & chemicals	9.1b	7.1b	8.0b
Chemical & hand picking	0.0c	3.6c	2.0c
Time of day			
Morning	81.8a	75.0a	78.0a
Evening	18.2b	25.0b	22.0b
Pesticide applicator			
Twigs	0.0b	0.0b	0.0b
Knapsack	100.0a	100.0a	100.0a
Places where chemicals are stored			
Store	90.9a	57.1a	72.0a
Group store	9.1b	35.7b	24.0b
House	0.0c	3.6c	2.0c
Outside	0.0c	3.6c	2.0c

Personal protective equipment			
Yes	99.0a	99.0a	99.0a
No	1.0b	1.0b	1.0b
Eating while handling pesticides			
No	98.0a	98.0a	98.0a
Yes	2.0b	2.0b	2.0b
Drinking while handling pesticides			
Yes	0.0b	3.6b	2.0b
No	100.0a	96.4a	98.0a
Fate of empty pesticide containers			
Disposal pit	59.1a	75.0a	68.0a
Group disposal pit	13.6b	25.0b	20.0b
Pit latrine	9.1b	0.0c	4.0c
Destroying by burning	18.2b	0.0c	8.0c

a & b denotes that there is a significant difference between the variables

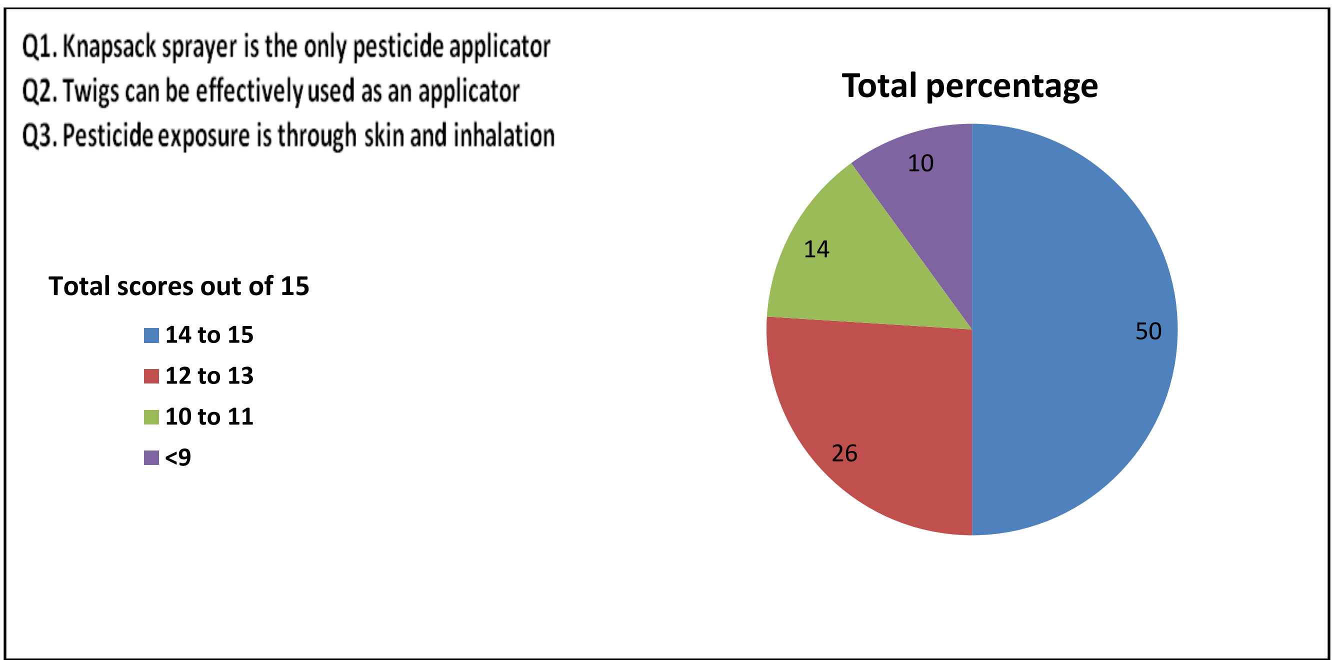

Figure 2: Response on practices on pesticide use in Kabaru location according to Likert Scale

Self-reported clinical effects following pesticide use

The major self-reported clinical effects experienced following pesticide use in this study included; headache, backache, dizziness, eye problems and sneezing (Figure 3).

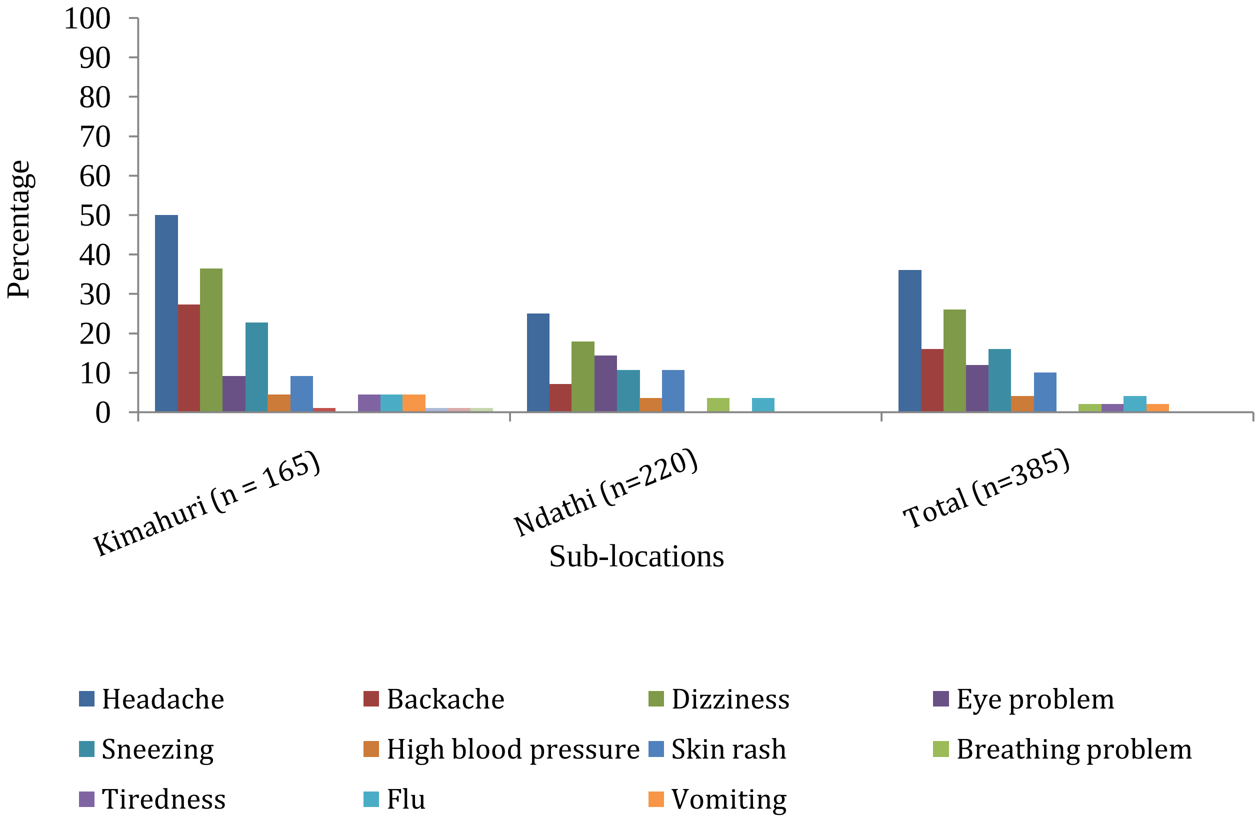

Figure 3: Self-reported clinical effects following pesticide use among bean smallholder farmers

Management of health effects following pesticide poisoning

In this study, most of the farmers did not go to hospital after experiencing signs and symptoms of pesticide poisoning and did not take medicine either but did wash their hands, took bath and removed PPE after experiencing the health effects of pesticide exposure as shown in Table 5 below.

Table 5: Management practices of health effects after pesticide use among bean smallholder farmers

Variables	Kimahuri Sub-location (n=165)	Ndathi Sub-location (n=220)	Total (n=385)
	Frequency (%)	Frequency (%)	Frequency (%)
Go to hospital			
Yes	4.6b	6.7b	5.7b
No	95.4a	93.3a	94.3a
$\chi 2$ (1)			0.6512
p-value			0.7220
Take medicine			
Yes	64.0a	32.4b	46.8a
No	36.0b	67.6a	53.2a
$\chi 2$ (1)			38.7979
p-value			<0.00001
Wash hands			
Yes	100.0a	100.0a	100.0a
No	0.0b	0.0b	0.0b
p-value			<0.00001

Take bath			
Yes	32.0b	86.2a	61.6a
No	68.0a	13.8b	38.4b
$\chi 2$ (1)			118.358
p-value			<0.00001
Remove PPE			
Yes	100.0a	100.0a	100.0a
No	0.0b	0.0b	0.0b
p-value			<0.00001

a & b denotes that there is a significant difference between the variables

Discussion

The pesticides used to control bean fly in this study were from the organophosphates (18%), pyrethroids (55%), neonicotinoids (18%), and carbamate (9%) chemical families. The WHO, (2010) classification of pesticide toxicity has been used by regulators to help determine which pesticides should be restricted into classes according to the pesticides' active ingredient. All the pesticides used belonged to WHO class II which are moderately hazardous chemicals. Nevertheless, these class II pesticides are still classified as Moderately hazardous they are known to have severe negative effect on human health and the environment, and therefore other less dangerous alternatives should still be promoted (Keifer, 2000). Farmers use these chemicals to control bean fly because they do not have adequate knowledge on the toxicity levels and they are readily available in the market. More training is needed to promote the use of other safer alternatives.

Using a Likert Scale, individual respondents were allowed to express the level to which they agreed or disagreed with a particular statement. A respondent who scored 15 out of 20 (75%) was termed to have "good" pesticide knowledge. Other pest control measures used apart from chemical pesticides included cultural methods such as crop rotation and mulching (Ampofo & Massomo, 1998) and hand picking. As found in this study, some farmers used them in combination with pesticides (Table 4). Chemical seed dressing is especially useful when used in combination with other approaches such as organic amendments to enhance soil fertility (Ampofo & Massomo, 1998). Hand picking and mulching are very tedious while crop rotation can only be utilized in the next planting season and so it cannot control pests instantly. These pest control measures do not have adverse effects on human, livestock and the environment.

With regard to methods of application, the majority (98%) reported that they used knapsack sprayers to apply chemicals. Knapsack sprayers are the recommended pesticide application devices and are widely used in most smallholder settings. The use of an appropriate device minimizes exposure to and wastage of pesticides. Our findings show that farmers in the study area do recognize the benefits of using the recommended equipment. Similar results were reported by Zimba & Zimudzi, 2016. Some (64%) disagreed that twigs can be effectively used to apply chemicals. The use of twigs leads to direct exposure and inhalation of chemicals as they are applied in a haphazard manner on the leaves of the plant. The inhalation of chemicals can result to pesticide poisoning or even death if in high doses. This method of chemical application also leads to wastage of pesticides.

The majority of respondents strongly agreed that pesticides are harmful to human health, livestock and the environment. Similar results were reported by (Y Mekonnen & T Agonafir, 2002; A. Ngowi et al., 2001; A. V. Ngowi et al., 2001; Oesterlund et al., 2014; and Pimentel, 2002). According to Pimentel 2002, human health and safety is threatened by the use of commercial pesticides with no mechanism to ensure food safety for consumers, and concern for the chronic effects of exposure. In addition, environmental impacts on wild life, crop pollinators and natural enemies are also severe (Stuart, 2003). The adverse effects of pesticides include the killing of beneficial insects, polluting the air, pesticide resistance, death, vomiting, headache and nausea (A. V. Ngowi et al., 2001). According to the Likert Scale described above, most of the farmers had "good" knowledge about the adverse effects of pesticides on human health and the environment.

All the surveyed farmers used personal protective equipment (PPE) to prevent pesticide exposure to the skin and inhalation and most of them read pesticide labels (Table 4). The low provision of protective clothing was a major risk factor for pesticide poisoning among farm workers in Zimbabwe although most of them read pesticide labels (Magauzi et al., 2011).

In many African countries, the poor utilization of protective clothing is a serious problem among small-scale farmers. This is because farmers use a particular type of protection for one part of the body (e.g. gloves) not for all parts (nose, hand, body and legs). Pesticides enter the body through inhalation, ingestion and through the skin. This is important because protective clothing is meant to prevent entry of pesticides into the body which can lead to acute pesticide poisoning (APP).

Majority (92%) of the farmers surveyed knew that pesticide containers have signs marking their toxicity levels but 60% did not know the signs marking the most dangerous pesticide. Ntow et al., 2006 & Oesterlund et al., 2014 also reported similar results where farmers had limited knowledge about toxicity color codes. According to Edson (1982), the colour codes banding precautionary pictograms relating to the toxicity of the product indicate toxicity in declining levels as follows: (i) PMS (Pantone Matching System) Red 199C for products classified under WHO class Ia and Ib; (ii) PMS yellow C for products classified under WHO class II; (iii) PMS Blue 293C for products classified under WHO class III; (iv) PMS Green 347C for unclassified products under the WHO classification(as shown in table 2). A study among farm workers in Zimbabwe by Magauzi et al., (2011), showed that ignorance of colour codes was a major problem and a risk factor for pesticide exposure. Understanding colour coding on pesticide containers is therefore important for preventing pesticide poisoning. Labels carry these colour codes to indicate the toxicity level of particular pesticides, and give instructions on use and first aid information. This information was acquired from radio, TV, fellow farmers and information from the pesticide labels. Moreover, the majority of the respondents had received pesticide training in the past. This training is important as farmers thereby learn how to safely handle pesticides, read labels, dilution measures, use of PPE, first aid precautions, the fate of empty containers and they generally gain an understanding of the impacts of pesticides on humans, livestock, environment, birds, beneficial insects and other non-targeted organisms in the ecosystem.

Some (90%) of the respondents used chemicals as their commonly used pest control measure and sprayed in the morning. There are various reasons why it is important to spray in the morning as plants absorb chemicals effectively and the air is more still than at other times of day. Still air is important for effective application and for personal protection. Spray directed at shrubs is scattered by the wind, and may endanger people and animals in the wind path. Many insects are most active early in the morning and around dusk, making very early morning and early evening the most effective times for insecticide application. Pesticide sprays require between 1 and 24 hours of drying time to maximize benefits. Moreover, problems caused by spraying during high temperatures usually show up as burns on foliage.

All the farmers did not eat or drink while handling chemicals. Eating and drinking increases the chances of pesticide entry in the body through the skin and ingestion. In Zimbabwe, studies on the occupational hazards of pesticide use and handling have shown that more than 50% of farm workers were exposed to organophosphates during spraying (Loewenson & Nhachi, 1996). Also of concern was the poor storage of the pesticides, as shown by the variation in storage facilities. Some (72%) stored their pesticides in their store and a small number in the group store. The Food and Agriculture Organization (FAO, 2006), has highlighted the importance of rules for the proper storage of pesticides in order to maintain product efficacy and to prevent contamination of the surroundings. Farmers should follow all disposal instructions on the pesticide labels. Most of them disposed the empty pesticide containers in the disposal pit in their homes and a few in their group disposal pit. The safe disposal of pesticide waste, including used containers, is an important aspect of pesticide management in order to minimize risk to human health and the environment (FAO, 2006; Karunamoorthi et al., 2011) which should be a policy of the Ministry of Health. Empty pesticide containers should not be re-used.

Accidental exposure or overexposure to pesticides can have serious consequences. The major self-reported clinical effects following pesticide use in this study included; headache, backache, dizziness, eye problems and sneezing (Figure 3). Other reported health effects include skin rash, skin irritation, breathing problems and flu. Similar results were reported by (Antle & Pingali, 1994; Asfaw, 2008; Farquhar et al., 2009; Harris et al., 2001; Lekei et al., 2014; Macharia et al., 2009; Maumbe & Swinton, 2003; Ohayo-Mitoko et al., 2000). Knowledge of these signs and symptoms will allow for prompt treatment and help prevent serious injury.

In this study, most of the farmers did not go to hospital after experiencing signs and symptoms of pesticide poisoning and did not take medicine. The key to surviving and recovering from pesticide poisoning is to seek treatment immediately. One should take emergency action immediately when you suspect and experience signs and symptoms of pesticide poisoning.

It is recommended that once one is exposed to a pesticide, to always wash the skin with soap or detergent with plenty of water and remove all the protective clothing after experiencing the health effects of pesticide exposure as shown in Table 5 above. Similar findings were reported by Reigart (2009), where for instance a pesticide applicator may not perceive the incident as being significant enough to seek care, particularly if he or she has been accustomed to low-level exposure scenarios on the job.

Conclusion

The findings of the present study clearly suggest that the farmers had reasonable knowledge about the hazards of pesticides. This is because there are two self-help groups in the region that educate farmers on pesticides. However, they had undesirable practices towards the safe use of pesticide management due to ignorance and limited income. Bean small-scale farmers in Kabaru location did not use the most hazardous pesticides of WHO class 1a and 1b. However the use of WHO class II pesticides together with inadequate knowledge and undesirable practices among the farmers such as incompleteness of PPE may lead to danger of acute intoxications, chronic health problems and environmental contamination.

Recommendations

The relevant authorities should initiate active health education campaigns and appropriate training programs to promote the safe use of pesticides and to eliminate or minimize the use of the most hazardous pesticides. Therefore training of farmers in Integrated Pest Management (IPM) methods, the practicing of proper hygiene and the use of personal protective equipment (PPE) when handling pesticides should be promoted. The use of bio-pesticides is affordable for the farmers and reduces the risk to humans and the environment while still yielding the expected outcome by not using hazardous chemicals.

Authors' contributions

B.M initiated the study, conducted the survey, analyzed the data and drafted the manuscript. J.G, G.K, C.B and S.N made conceptual contributions, conducted the survey and reviewed the draft manuscript. All authors have read and approved the manuscript.

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