Environmental management and sustainability

Scientific and technological research article

Knowledge and practical use of pesticides in Cuba

Conocimiento y uso práctico de plaguicidas en Cuba

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Subject Editor: Felipe Borrero Echeverry (Corporación Colombiana de Investigación Agropecuaria [AGROSAVIA])

Date of receipt: 30/01/2019
Date of approval: 08/08/2019

How to cite this article: López-Dávila, E., Ramos Torres, L., Houbraken, M., Du Laing, G., Romero Romero, O., & Spanoghe, P. (2020). Knowledge and practical use of pesticides in Cuba. *Ciencia y Tecnología Agropecuaria*, *21*(1), e1282

DOI: https://doi.org/10.21930/rcta.vol21_num1_art:1282

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Abstract

The unauthorized use of pesticides applied at inappropriate times and/or in unregistered crops is a potential risk to the environment and also to human health. The aim of this study was to assess the level of knowledge and awareness of farmers on the use, risk, and hazards associated with the exposure to pesticides in the agricultural region of Sancti Spíritus, Cuba. To comply with the objective, 124 farmers of this province were surveyed. The results were analyzed initially through a descriptive analysis and then, performing an association analysis using the Chi-Square test and Spearman´s correlations, employing the statistical package SPSS version 20.0. The results showed that only 28.3 % of the farmers had received specific training on pesticides. Personal experience was the main driver for decisions about which pesticides to use and how it would be applied. About 35.8 % of the farmers stored pesticides in unmarked containers, such as soft drink bottles. The empty containers are stored to be incinerated (31.7 %) or reused (42.6 %) for pesticides, water, or fuel. Around 90 % of the farmers surveyed do not use personal protective equipment. The study concludes that the lack of knowledge and use of personal protective equipment, the inability to understand the labels and also the low risk-perception are the main causes of exposure to pesticides and the health risk for workers and nearby residents, as well as the damages caused to the environment.

Keywords: occupational exposure, organophosphates, personal protection equipment, plant protection products, small lot farmers

Resumen

El uso no autorizado de plaguicidas, como la aplicación en momentos inadecuados o en cultivos no registrados, es un riesgo potencial para el medio ambiente y la salud humana. El objetivo de este estudio fue evaluar el nivel de conocimiento y concientización entre los agricultores sobre el uso, riesgo y peligros asociados con la exposición a plaguicidas en la región agrícola de Sancti Spíritus, Cuba. Para el desarrollo del objetivo se encuestaron 124 campesinos de la provincia. Los resultados fueron analizados a partir de un análisis descriptivo inicial y luego a través de un análisis de asociación mediante la prueba Chi-Cuadrado y Correlaciones de Spearman, empleando el paquete estadístico SPSS versión 20.0. Los resultados mostraron que solo el 28,3 % de los agricultores había recibido capacitación específica en plaguicidas. La experiencia personal es el principal impulsor de las decisiones sobre qué plaguicidas usar y cómo utilizarlo. El 35,8 % de los agricultores almacenó plaguicidas en recipientes sin marcar, como botellas de refrescos. Los contenedores vacíos se almacenan para ser incinerados (31,7 %) o reutilizados (42,6 %) para plaguicidas, agua o gasolina. Alrededor del 90 % de los agricultores no utiliza equipos de protección personal. El estudio concluye que la falta de conocimiento, el no uso de equipo de protección personal, la incapacidad para entender las etiquetas y la baja percepción de riesgos son las principales causas de la exposición a los plaguicidas y el riesgo para la salud de los trabajadores y residentes cercanos, así como de los daños al medio ambiente.

Palabras clave: equipos de protección personal, exposición ocupacional, organofosforados, pequeños agricultores, productos fitosanitarios

Introduction

Since World War II, food production has tripled, and food availability has increased by more than 40 % worldwide (da Silva, 2015); despite this, more than half of the world's population suffers from insufficient food consumption (da Silva, 2015). Although the use of certain chemicals favors the process of food production with certain risks (Obopile, Munthali, & Matilo, 2008), it is also true that misapplication of pesticides and application to unregistered crops make these substances a potential risk for the environment, affecting soil fertility, beneficial organisms, wildlife, freshwater reservoirs, and human health (Bustamante-Villarroel et al., 2014; Leyva-Morales et al., 2014; Mokhele, 2011). Some authors consider that global pesticide use will be 2.7 times higher in 2050 compared to 2000, exposing humans and the environment to considerably higher levels of risk (Kumari & Reddy, 2013).

No pesticide lacks toxicity (del Puerto-Rodríguez, Suárez-Tamayo & Palacio-Estrada, 2014). Toxicity depends on the rate at which the pesticide is absorbed and accumulated (Arriaga-Barrios, 2012; Damalas & Eleftherohorinos, 2011; Tsimbiri, Moturi, Sawe, Henley, & Bend, 2015). Pesticides can cause severe damage to humans as well as to wildlife, such as teratogenic, carcinogenic, mutagenic, and neurotoxic effects (Botião-Nerilo et al., 2014; Mwila, Burton, Van Dyk, & Pletschke, 2013; World Health Organization [WHO], 2009), since humans and wildlife have several physiological functions similar to those of pests (Bustamante-Villarroel et al., 2014).

Authors from different regions of the world claim that exposure of small farmers and residents to pesticides occurs because inadequate preventive measures are taken during mixing and application (Ntzani, Chondrogiorgi, Ntritsos, Evangelou, & Tzoulaki, 2013; Tsimbiri et al., 2015). Studies suggest that the lack of protective equipment, application habits, and misconceptions facilitates poisoning (Doan-Ngoc, 2014; Varona-Uribe et al., 2012). Exposure can be seriously reduced when workers wear personal protective equipment (overalls, masks, and gloves) and are provided with water to wash their hands (Eskenazi et al., 2007). According to the Food and Agriculture Organization of the United Nations (FAO), most pesticide poisonings occur in regions where the level of knowledge about pesticides is reported to be low to moderate, and where there are inefficient or no systems of regulation, control, health, or education in place (Food and Agriculture Organization [FAO], 2014; Lekei, Ngowi, & London, 2014; Nalwanga & Ssempebwa, 2011).

Pictograms on pesticide labels communicate the risks and the use of personal protective equipment (Ajayi & Akinnifesi, 2007; Lekei et al., 2014; Negatu, Kromhout, Mekonnen & Vermeulen, 2016; Roberts & Routt Reigart, 2013; Rother, 2008). The label is the only source of information for the user to understand the risks of a specific pesticide. Recent studies also warn about the lack of knowledge and research on factors determining pesticide exposure for at-risk populations such as pregnant women, the elderly, and children (da Silva, 2015; Deziel et al., 2015; Lewis et al., 2015), a situation that is also found in Cuba.

In 1997, the Cuban government established a national integrated pest management program which includes the use of biological products (Figueroa-González & Pérez-Consuegra 2012; Vázquez-Moreno 2012). This program became the Environmental Law (Asamblea Nacional del Poder Popular de Cuba [National Assembly of the Popular Power of Cuba], 1997) in 1998, setting the rules for sustainable agriculture. Ministerio de Ciencia, Tecnología y Medio Ambiente [Ministry of Science, Technology and Environment] issued in 2007-2010 a national environmental strategy as a target for 2010, which stated that 80 % of the pests and diseases control activities in crops that are carried out in the country should be conducted with natural products or biopesticides (Hernández-Núñez & Pérez-Consuegra, 2012; Rosquete-Pérez, 2011).

However, to increase the productivity of agricultural systems, technological packages have been introduced, integrating the use of chemical pesticides as the main component of the production system (Aguilar, Calero, Rodriguez & Muniz, 2015; Ponce et al., 2015). To date, there are no reports on compliance with the 2010 targets. Furthermore, the number of pesticide poisonings reported by Centro Nacional de Toxicología [National Toxicology Center] in the last decade increased from 237 to 390 cases per year (Mederos-Gómez, Lara-Fernández, Miranda-Gómez & Lorenzo, 2014; Pérez-Rodríguez, Álvarez-Delgado, David-Baldo & Capote-Marrero, 2012). Most of the pesticides involved in these poisonings belong to a limited number of chemical groups, such as pyrethroids, organophosphates, carbamates, and organochlorines.

In the province of Sancti Spíritus, agricultural production is a fundamental economy driver. For the rural population (27.43 % of the provincial population), it is one of the primary sources of employment and financial support (National Bureau of Statistics and Information, 2015). Besides, as yields of priority crops increase in the province to replace imports, larger quantities of pesticides (Plant Protection Products [PPP]) have been used (over 1,200 tons of active ingredient during the period 2011-2014) at an average ratio of 1.07 kg of active ingredient per hectare of cultivated land per year. Thus, the inhabitants of rural areas are a vulnerable segment of the population because they have the highest risk of exposure to pesticides. In this context, studies related to risk perception are essential for understanding the vulnerability of populations, and to plan interventions. To date, no studies on the use and knowledge of chemical PPPs by Cuban farmers and the resulting consequences for the environment, have been published. The risks that PPPs pose to human and environmental health have motivated this study. Accordingly, the aims of this study were: (i) to assess the level of knowledge and perception of risks among the farmers of the Sancti Spíritus region on the use of PPPs, as well as (ii) the main risks to human health and the environment from current inappropriate practices in the use of PPPs.

Materials and methods

Study area and population

The study was performed in the province of Sancti Spíritus, about 400 km southeast of Havana City (latitude 21°53'45.5" N, longitude -79°26'46.8" W). The province is situated in the center of the island, with costs to the north and also to the south, and has an area of 6,777.3 km^2 with eight municipalities and 466,431 inhabitants (National Bureau of Statistics and Information, 2015). Sancti Spíritus has a typical tropical climate suitable for agricultural activities with an average annual temperature of 25.3 °C, 78 % of relative humidity and average annual precipitation of 1,374.5 mm. The province has varied agriculture due to its soil diversity (11 different genetic soil types) (National Bureau of Statistics and Information, 2015); the main crops cultivated are beans, rice, roots and tubers (e.g., potatoes), vegetables (e.g., cucumber, garlic, onion, sweet, pepper and tomato), fruits (e.g., guava and mango), maize and tobacco.

Survey

A questionnaire was developed based on previous research (Houbraken, Bauweraerts, Fevery, Labeke & Spanoghe, 2016). The input of specialists in psychology, sociocultural studies, agronomists, and some farmers were used to adapt the questions and the language to correspond to local practices.
A total of 124 geographically random households of the province were surveyed. Of these, 120 questionnaires were analyzed, and four were not analyzed. The sample size was calculated from the list of the leading farmers (190), in terms of major pesticide applicators (who have a significant impact on provincial agricultural production, and pressure of pesticide traces on the environment and human health), given by the municipal directorates of agriculture and varied cropping. The equation described by Cochran (1977), with an error rate of 5 % and a confidence level of 95 %, was used.

The survey (table 1) focused on:

1. Socio-demographic information (gender, age, and educational level) and farming practices.
2. Pesticide application knowledge (pesticide usage, pre-harvest intervals, and final disposal of pesticide containers, management of unused pesticide, and label comprehension).
3. The awareness level of the hazards related to pesticide use.

In some cases, it was necessary to conduct face-to-face interviews during the survey to provide participants with clear explanations and minimize the risk of misunderstanding. To ensure correct interpretation of the answers provided, we were assisted by a crop protection specialist from Instituto Provincial de Protección Fitosanitaria who attended the surveys. This specialist also recruited the farmers through his contacts in each municipality. Participation in the study was completely voluntary. The interviews, i.e., answering the survey and visiting the area (pesticide storage room, application equipment, and crops), took approximately one hour.

In order to evaluate the level of knowledge of each farmer concerning the information provided by pesticide labels and pictograms, participants were asked to examine an image of a pesticide label known to them (profenofos) and were then invited to identify specific information necessary for the proper use of the product. Specific questions were asked about: the name of the pesticide, type of formulation, application dose, instructions for use, environmental damage, precautions to be taken, the active ingredient, pesticide category, and time of re-entry into the field. In addition, pictures of 16 standard pictograms found on labels (indicating those depicting proper handling and precautions) were shown, and participants were asked to identify their meaning. Following the evaluation criteria established by the Cuban Ministry of Education, the results were scored as follows. If 90 % or a higher percentage of correct answers were obtained by the farmer, his/her score was "excellent"; if the farmer had 80 %-89 % correct answers, his/her score was "good"; if the farmer obtained 60 %-79 % of correct answers, his/her knowledge was rated as "average"; and when less than 60 % of correct answers were obtained, his/her knowledge was classified as "poor".

Table 1. Questions to farmers in order to evaluate the level of knowledge, awareness, and risk related to pesticide usage

Question
Socio-demographic background of study farm workers
What is your: age / gender / education level / family members / total hectares
Did you receive training to apply pesticides?
How do you decide to apply a pesticide?

(Continue on next page)

(Continuation of table 1)

Question
Knowledge and use of pesticides
Where do you store pesticides?
Do you follow the instructions on the label?
What are your sources of pesticide knowledge?
What outfit do you usually wear during pesticide application?
Where do you prepare the spray solution?
How close to a water body, do you spray pesticides?
How do you dispose of empty pesticide containers?
Pesticide application
What do you mainly spray against?
Which products do you use?
How many hours do you work in the field?
How many pesticides do you apply per month?
What type of equipment do you use to apply pesticides?
How do you manage leftover pesticide solutions?
How do you clean the equipment for pesticide application and personal protection?
Which kinds of measures do you take after applying pesticides?
Farmers' risk perception on human and environmental health by the use of pesticides
What is the field re-entry interval?
What is the pre-harvest interval?
What is the trend of your pesticide use during the past five years?
Do you consider that the use of pesticides can affect your health and the environment?
What are the health risks related to working with pesticides?

Source: Elaborated by the authors

Data analysis

Statistical analyses were completed using the Statistical Package for Social Sciences (SPSS) version 20.0. Chi-square tests ($p < 0.05$) were used to analyze relationships between the answers regarding pesticide use training and those concerning knowledge of the information provided on the label and pictograms. A Spearman's rank correlation ($p < 0.01$ and $p < 0.05$) was used to evaluate the correlation between trained farmers and knowledge of the information provided on the label and picto-grams, with their awareness level on the hazard of pesticides to human health and also to the environment.

Results

Socio-demographic background of the farmers

In total, 120 small farmers cultivating varied crops depending on the season, such as tobacco, grains (e.g., beans, corn and rice), vegetables (e.g., cucumber, garlic, onion, sweet pepper and tomato,), fruits (e.g., guava and mango), tubers (e.g., potato and sweet potato), and roots (e.g., cassava) from the Sancti Spíritus province, were surveyed from April until early June of 2016 (table 2).

The total number of family members was mostly 3-5 (19.2 %-20.8 %). All persons older than 18 years were considered adults. The average size of a small farm plot was 2 ha, and for the farmers whose main crop is rice, it was 13.4 ha.

Only 28.3 % of the farmers had received specialized courses in pesticide management. This could be the reason why 40.1 % of the farmers indicated that they apply pesticides to prevent the occurrence of pests and/or diseases, while 44.2 % apply them only when these have already attacked.

Table 2. Social and demographic background of the interviewees

Category	Variables	Farmer	
		n	%
Gender	Male	104	86.7
	Female	16	13.3
Age	> 21	4	3.3
	21 - 30	7	5.8
	31 - 40	18	15.0
	41 - 50	44	36.7
	51 - 60	31	25.8
	< 61	16	13.3
Level of education	University	19	15.8
	High school	66	55.0
	Middle school	26	21.7
	Primary school	9	7.5
	Illiteracy	0	0.0

Source: Elaborated by the authors

Knowledge and use of pesticides by farmers

The fact that 71.7 % of farmers indicated that they follow the instructions on the label suggests a low human exposure risk. Considering that only 34.2 % of the farmers use pesticides from original containers, while 35.8 % use another type of container (e.g., water or soft drink bottle) to be filled with the pesticide, "low risk to human exposure" might be inaccurate; hence, lack of risk-perception may dominate. The remaining farmers (30 %) use both methods. A significant correlation at the 0.01 level ($r = 0.386$, $p < 0.01$) was found between those parameters. The answers given by the farmers in the test used to assess the knowledge of the information provided by the pesticide labels and their pictograms were used to confirm the previous point. It was found that in terms of labels, 60 % of the farmers, demonstrated poor knowledge; further, 20.8 % showed excellent knowledge, 5 % demonstrated good knowledge, and 14.2 % showed average knowledge. Knowledge regarding the meaning of the pictograms was also low, i.e., 77.5 % of the surveyed scored poor, while only 5 % scored excellent, 5.8 % good, and 11.7 % average. As only 28.3 % of the farmers had received specialized courses in pesticide management, there is no statistical evidence to say that there is dependence or correlation between pesticide use training and knowledge of the information provided on the label ($\chi^2 = 0.234$; $p = 0.628$) ($r = 0.07$; $p = 0.406$) and pictograms ($\chi^2 = 0.178$; $p = 0.673$) ($r = 0.069$; $p = 0.425$). This indicates a need for training farmers to increase knowledge about the use and management of pesticides.

A positive relationship was found between poor knowledge of pictogram with never using a mask ($\chi^2 = 8.472$; $p = 0.014$), protective glasses ($\chi^2 = 4.520$; $p = 0.003$), and a face mask ($\chi^2 = 6.223$; $p = 0.045$). A similar relationship was found between poor knowledge of labels and never using gloves ($\chi^2 = 14.362$; $p = 0.026$) or a mask ($\chi^2 = 6.155$; $p = 0.046$), suggesting a low risk perception in all of these examples.

The survey showed that 57.5 % of the farmers store pesticides in a locked storeroom outside their house, but 28.3 % store them in nonspecific and unlocked locations. Only 5.0 % keeps the pesticide containers inside their home. Locked storage outside the house to deposit empty pesticides containers for reuse, incineration, or disposal was found in 50.9 % of the farms, with a positive statistical relationship between reuse of empty containers and the poor knowledge score regarding the meaning of pictograms ($\chi^2 = 27.024$; $p = 0.008$). Only a small percentage of farmers (4.8 %) considered sending empty containers back to the distributor. This might be due to the habit of reusing containers for other products without considering the risks.

On the other hand, when farmers decide how to manage a particular disease or pest, 55.5 % primarily use their previous experience with pesticide products to protect their crops. If that strategy does not work, 26.7 % try another pesticide with a similar function. Further, 15.8 % ask their neighbors for suggestions, while only 14.2 % of the farmers were advised by specialists and phytosanitary technicians. On the other hand, 91.7 % of the farmers prepared the product mixture in the field to be sprayed, and 64.2 % use a measuring cup to apply the right dose.

Concerning the selection of pesticides used, the answers were evaluated by regional and provincial specialists in crop protection, as well as pests and diseases experts (specialists that decides who meet the requisites to obtaining a certificate for the use of PPPs). About 36.8 % of the farmers make excellent selections of pesticides to use; 40.1 % make appropriate selections, and 15.1 % make poor decisions on which pesticides to use. On the other hand, depending on the level of pest infestation, only 19.1 % used the required dose of pesticides, and 57 % of the farmers surveyed do not use the appropriate doses of pesticides. A combination of inappropriate doses and wrong pesticide selection causes a serious pesticide resistance problem, which is one of the main causes identified by farmers as a consequence of the increase in the use of pesticides in the last five years. A similar misuse has been found in a region of Bolivia (Bustamante-Villarroel et al., 2014).

The use frequency of personal protective equipment by farmers during pesticide mixing and application is shown in table. As a national tradition, the uniform of a farmer includes a hat, long sleeve shirt, long trousers, and boots; this is the reason why their frequency values were so high (figure 1). On the other hand, the use of personal protective equipment such as gloves, protective glasses, a face mask, and a full mask with a respirator are not frequent. A positive correlation was found between farmers who take training courses with farmers who used gloves and a full mask with a respirator. Statistical evidence like this helps to demonstrate the need to train farmers, which would increase their risk perception and reduce the adverse consequences on humans and also on the environment. Nonetheless, 91.7 % of the surveyed farmers have a water body on their farm or close to their farm. However, 59.2 % of them spray pesticides at 20 m or farther away from the surface water, whereas 15 % of the farmers applied pesticides within 5 m of the water bodies.

Table 3. Use of personal protective equipment during application of pesticides

Category	Variables	Farmer		Observations
		n	%	
To protect the face and hand	Gloves	25	20.8	r = 0.234, $p < 0.01$ Have you received training to apply pesticides?
	Glasses	10	8.3	r = 0.095, $p = 0.268$ Have you received training to apply pesticides?
	Face mask	12	10.0	r = 0.044, $p = 0.604$ Have you received training to apply pesticides?
	Full mask + respirator	19	15.8	r = 0.277, $p < 0.01$ Have you received training to apply pesticides?

Answers that do not reach 100 %: the farmer never used the element mentioned. $^{*} p < 0{,}05$, $^{**} p < 0{,}01$.
Source: Elaborated by the authors

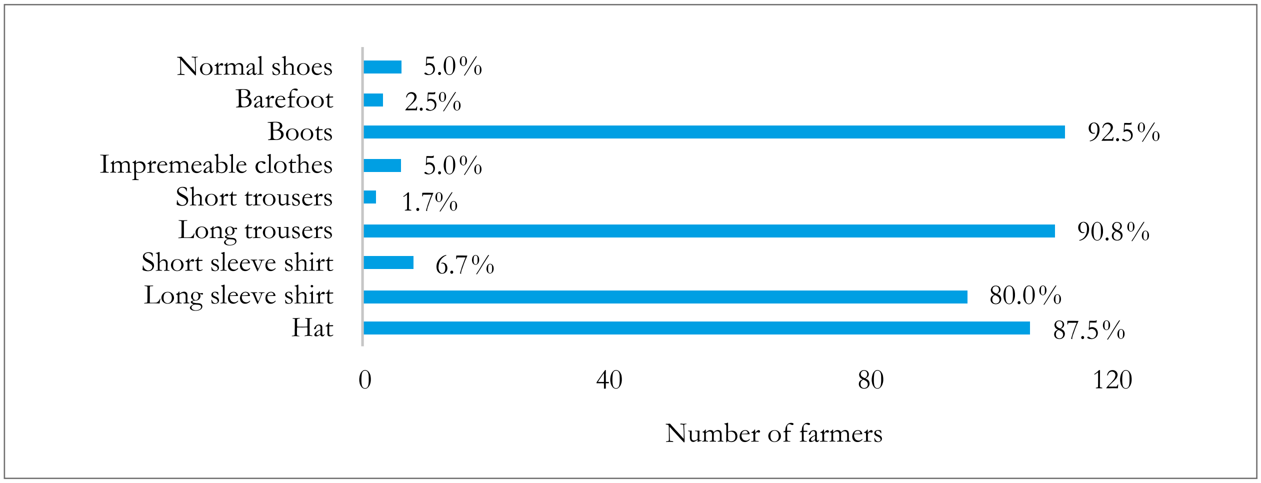

Figure 1. Clothes to protect the body when pesticides are applied.
* If answers do not reach 100 %: farmers never used the element mentioned.
Source: Elaborated by the authors

Pesticide use

About 54.1 % of the farmers spend around 8 h/day in the field carrying out cultivation activities or monitoring their crops for the presence of pests. The pesticide application program is specific to each type of crop (before the cultivation campaign begins, a Crop Protection Specialists from the Provincial Institute of Plant Protection elaborates a management plan for the PPPs that should be used if necessary and their forms of use based on national guidelines). But in interviews with the specialists, they point out that there is no adequate communication with the farmers to know beforehand what crops will be planted as well as their quantity. Therefore, many farmers decide for themselves what crops to plant and end up applying PPPs obtained in previous campaigns or designated for other crops. Application frequency ranged from once a week (29.2 %) to three times a week (33.3 %), where the most common type of pesticide application equipment is the backpack sprayer (87.5 %). Spraying pesticides was reported to take 1-4 h/day, where fields of 1 ha or more often required 4 hours (40.4 %). Farmers cannot purchase other pesticide application equipment because they are not available in Cuba. Although pesticides are being used primarily to treat pests in their crops (59.1 % of farmers surveyed), 18.8 % of the farmers use pesticides to manage weeds.

The farmers surveyed listed 95 different commercial products (see supplementary material). In total, these included 67 active ingredients, of which 27 were insecticides, 22 fungicides, and 18 herbicides. The most commonly cited pesticides were carbamate, dithiocarbamate, triazole, organophosphates, and pyrethroids. From the group of pesticides reported, only a limited number of active ingredients are relevant considering they are applied to many crops (vegetables, fruits, cereals, and others). These active ingredients include compounds such as tebuconazole, bifenthrin, methamidophos, glyphosate, cypermethrin, emamectin benzoate, mancozeb, acephate, deltamethrin, and copper oxychloride. It is essential to mention that compounds used many years ago, such as methamidophos and acephate that have already been eliminated from their use in Europe due to their toxicity, are still used by farmers in Cuba. Generally, farmers apply 14 backpack tanks (16 L) per ha (67 %) in a growing season.
Insecticides (46.5 %) as well as fungicides (24.3 %), depending on the crop, are commonly used. Compared to insecticides and fungicides, herbicides are used much less. Farmers prefer to perform weeding with a hoe, or a plow pulled by oxen.

Leftover pesticide solutions are sprayed over the crop by 83.7 % of the farmers. About 2.5 % of the farmers store pesticide solution leftovers in locked storage rooms away from their house; meanwhile, 3.3 % reported spraying leftover pesticide in or around the house.

Nevertheless, 90 % of the farmers immediately clean spraying equipment with water after an application, with a significant correlation with trained farmers (r = 0.174, $p < 0.05$). However, 10 % of the farmers clean their tank only once per week. Personal protective equipment used during the application is cleaned immediately after usage by 88.35 % of the farmers, whereas 8.3 % clean it only weekly. Moreover, 76 % of the farmers take a shower and change their clothes after applying pesticides, while the remaining, only wash their hands and face and continue with their activities, i.e., they have a high health risk percentage.

Risk perception for human and environmental health

Farmers were not familiar with the concept of safe re-entry times for treated fields. Only 7.5 % adhere to the re-entry time on the label (without a correlation with trained farmers r = 0.135; $p = 0.094$); 69.2 % wait by default one day; and 12.5 % wait several days. The level of risk can be reduced by using the appropriate personal protective equipment when re-entering a field, such as gloves, a mask, and a respiratory filter. Pre-harvest interval is also not fully understood. Only 22 % adhere to the pre-harvest interval indicated on the label, showing, in this case, a positive correlation with the trained farmers (r = 0.246; $p < 0.01$); 55 % wait one week; and 16 % of the farmers wait more than one week and up to several weeks.

Table 4. Risk perception of the farmers by using pesticides

Category	Variables	Farmer		Observations
		n	%	
What is the trend of your pesticide use in the past 5 years?				
	Increase	99	82.5	
	Constant	7	5.8	
	Decrease	9	7.5	
Pesticides can affect…				
	Cattle and animal diversity	81	67.5	r = 0.598** Pesticides can affect your life environment
	Natural enemies of pests	77	64.2	r = 0.601** Pesticides can affect your life environment

(Continue on next page)

(Continuation of table 4)

Category	Variables	Farmer		Observations
		n	%	
Pesticides can affect...				
	Health of agricultural workers	113	94.2	r = 0.169; p = 0.054 Pesticides can affect your life environment
	Health of consumers	84	70.0	r = 0.593** Pesticides can affect your life environment
	Soil fertility	54	45.0	r = 0.610** Pesticides can affect your life environment
Pesticides can affect your health				
	Yes	115	95.8	r = 0.153; p = 0.085 Have you received training to apply pesticides?
	No	2	1.7	
Pesticides can enter into the body through the...				
	skin	92	76.7	r = 0.129; *p* = 0.147 Pesticides can affect your health
		113	94.2	r = 0.247; *p* = 0.006 Pesticides can affect your health
	mouth	106	88.3	r = 0.139; *p* = 0.122 Pesticides can affect your health
Have you suffered any effects after applying pesticides?				
	Yes	53	44.2	χ^2 = 5.362* Reused empty containers χ^2 = 9.684** Decided to apply a pesticide by his/her own decision
	No	66	55.0	

If the answers do not reach 100 %: the farmers did not answer. * $p < 0.05$, ** $p < 0.01$.
Source: Elaborated by the authors

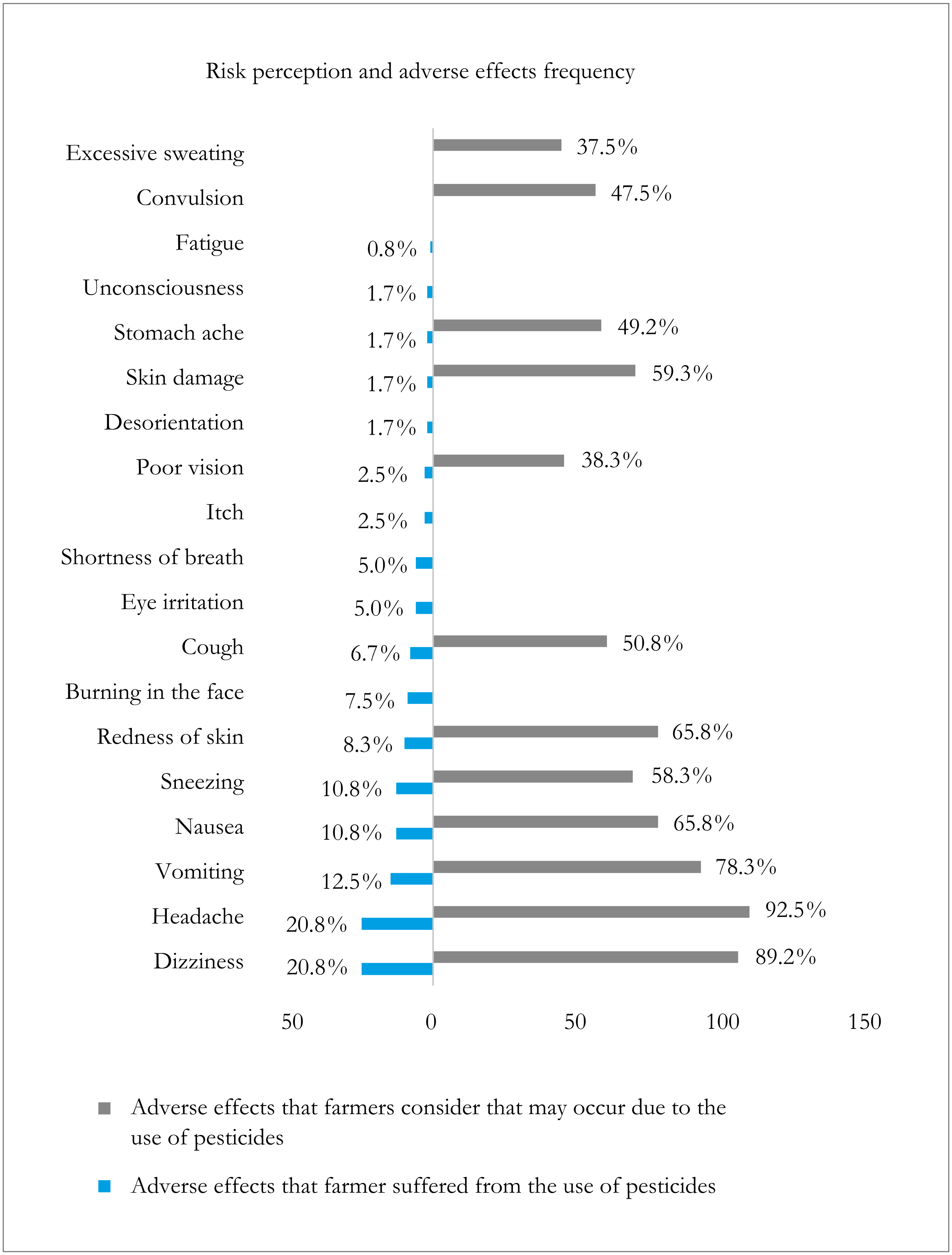

Figure 2. Risk perception and adverse effects frequency due to the use of pesticides. Answers that do not reach 100 %: the farmer did not respond.
Source: Elaborated by the authors

Farmers mentioned as the main reasons for the increased use of pesticides (table 4): pest resistance, ineffective pesticides, increases in populations of insect pests and their damage, increased agricultural area, and budget. Similar reasons were cited by Ngowi, Mbise, Ijani, London, and Ajayi (2007) for farmers cultivating similar crops in a tropical climate area. More than half of the farmers recognized that pesticides can adversely affect human health, with headache, dizziness, vomiting, and nausea, being the most significant (figure 2). Table 4 shows that nearly half of the farmers surveyed have suffered adverse effects, also finding a chi-square relationship ($\chi^2 = 9.684; p < 0.01$) with how they decide to apply a pesticide (68.3 % do it by their own decision). Moreover, a relationship ($\chi^2 = 5.362; p < 0.05$) was also found between suffering adverse effects with the reuse of empty containers. The main adverse effects suffered cited by the farmers (i.e., dizziness, headache, vomiting, and nausea) are well correlated with the main adverse effects recognized by them (figure 2).

Discussion

Background of the farm workers

Farmers were mainly in the age groups of 41-50 years (36.7 %) and 51-60 years (25.8 %), with a predominance of males (86.7 %) as the head of household (see table 2). Similar percentages were cited in other studies (Leungo, Obopile, Madisa & Assefa, 2012; Rother, 2008; Tsimbiri et al., 2015). The farmers surveyed had a good level of education (55 % completed high school, and 15.8 % obtained a university degree) (Silva et al., 2015; Tsimbiri et al., 2015).

On the other hand, a low level of training in the use of pesticides is found among farmers as only 28.3 % had received specialized courses in this topic (Lekei et al., 2014; Rother, 2008). However, the education level will contribute to the knowledge of farmers once they receive training courses. Based on the analysis of the relationship between the knowledge obtained in specialized courses and the information present on the labels and pictograms of the pesticide containers, we conclude that it will be essential to increase the offer of specialized courses, independent of the education level, to improve farmers' knowledge and use of the pesticides, as well as the way in which they perceive pesticides. In this sense, 55.5 % indicated that their "own decision" was the source of knowledge on how to apply a pesticide. This demonstrates that there is currently not enough communication between farmers and phytosanitary consultants. The former used their experience from previous cropping seasons to evaluate their upcoming crop protection strategy upon observing resistant pests or diseases.

This lack of knowledge leads to the misuse of pesticides, resulting in failed pest control due to inappropriate selection of products, inadequate dose, or wrong application timing. Cuban phytosanitary consultants believe that farmers understand that pesticides are to be used to prevent the occurrence of pests and/or diseases (i.e., not to be used prophylactically). They are to be applied in specific crops when infestation levels have reached an economic threshold, as established in various monitoring and prediction methodologies for pests and diseases legislated in Cuba. This evidence of the application of an undetermined number of agrochemicals at unjustified times means that the potential benefits of biological pest control are not being exploited (Rosquete-Pérez, 2011).

Training farmers on pesticide safety could help prevent adverse health effects associated with exposure and improve interpretation of pesticide label information. Cuba should consider offering training courses to improve farmers' knowledge concerning the use of pesticides, as many other countries do.

Risks of daily pesticide management

Quality of pesticide containers, proper storage, and disposal of empty containers are issues that farmers must be aware of to maintain a safe environment. Support from governments and commercial organizations in providing means for the safe disposal of used pesticide containers would benefit farmers, their families, and the environment. Most farmers (65.8 %) receive pesticides in a container that they provide to the seller (secondary containers that include soft drink bottles) or refill a previously used container. This poses a significant risk to the safety of operators, other members of the household, crops, and the environment in general. In most cases, the containers in which the pesticides were packaged had no label or only a small paper affixed with the product name. In Tanzania, Lekei et al. (2014) observed the same situation as in Cuba, with almost no information being found on the containers used to store pesticides, as farmers use different forms of reusable containers or bottles (Lekei et al., 2014). This limits the knowledge that farmers can acquire to handle pesticides safely (Ngowi et al., 2007; Rother, 2008).

Storage of pesticides near the house can easily contaminate consumer products and compromises the health of the applicator's family (particularly children). An even higher risk occurs when pesticides are stored inside the house. As with other developing countries, Cuba is not immune to these deficiencies. Another risk observed in Cuba is the misuse of empty pesticide containers. Only 4.8 % of these empty containers are sent back to the distributor, and a high percentage (50.9 %), as observed by Lekei et al. (2014) and Tsimbiri et al. (2015), are kept by farmers for storing other pesticides, fuel, and even water, food, and other household products. Only a small number of containers are burned. Inappropriate disposal of empty pesticide containers confirms the low awareness of farmers concerning the risk to which they are exposed (Negatu et al., 2016).

Personal protection equipment is vital and must be used during both the preparation and application of pesticides. This protects the operator from getting in contact with the pesticide and suffering its possible adverse consequences. This equipment must be cleaned after use or be replaced (Houbraken et al., 2016). In the present study, a high percentage of farmers (91 %) did not use personal protection equipment that could protect them from exposure to pesticides (e.g., impermeable clothes, gloves, a mask, a face protector, and a full mask + respirator). Protective equipment also enhances the safety and health of the operators or workers when re-entering a treated crop (Ajayi & Akinnifesi, 2007; Tsimbiri et al., 2015). Some farmers claim that in a tropical environment the use of these means of protection is difficult due to the high humidity, high temperatures, and high costs. Other studies confirm this same opinion (Clarke, Levy, Spurgeon & Calvert, 1997). In addition to cleaning the protective equipment, it is essential that the applicator showers and changes clothes before continuing to work, especially if protective equipment was not worn, to remove any remaining pesticides and reduce the risk of adverse reactions. Most farmers surveyed (76 %) do this, favoring their safety and decreasing the risk of suffering an adverse event. These results are similar to other studies carried out in developing countries (Ibitayo, 2006; Negatu et al., 2016; Varona-Uribe et al., 2012). On the other hand, another group of farmers did not perform this routine task, only washing their hands and face before continuing to work. The risk in which these farmers place themselves is alarming, especially for those who expose themselves to 4 hours (40.4 %) of spraying, and then continue their workday of 8 hours (54.1 %).

The number of applications per week carried out by farmers also gives a measure of the risk to which applicators, field workers, and the environment are exposed. Considering that most farmers are engaged in various crops such as tobacco, rice, tomato, beans, fruits, and vegetables, there is a high frequency of applications per week (33.3 % apply three times per week). Similar alarming spraying frequencies have been observed in other countries on similar crops (Leungo et al., 2012; Ngowi et al., 2007).

The farmer calculates the exact amount of pesticide to use in order to minimize the leftover mixture. Farmers expressed that pesticides were expensive to waste and continued spraying until the solution was finished. About 3.3 % of the farmers spray any pesticide leftovers around the house, increasing the risk for all the persons in the household as well as their pets. In a study in India (Kumari & Reddy, 2013), farmers showed similar customs, keeping pesticide leftovers in drinking container for later use, and 2.5 % keep these leftovers to be used another day.

Knowledge levels

For a realistic perception of pesticide risk, it is vital to know the information provided on the pesticide label and their pictograms. Pesticide labels and pictograms have an essential role as they are used globally by pesticide manufacturers and regulatory agencies to communicate general information to applicators (Ajayi & Akinnifesi, 2007; Waichman, Eve & da Silva, 2007). Misinterpretation or ignorance of the label or pictogram information could lead to incorrect application dosages, dangerous re-entry times, and lack of protective equipment usage (Lekei et al., 2014; Rother, 2008). Cuban farmers, similar to those in India, expressed that it is difficult to understand use instructions and safety procedures on labels because most of them have small prints, use a difficult vocabulary, or are written in a foreign language (Kumari & Reddy, 2013). If the farmer cannot understand the information on the label, mistakes will occur. Cuban farmers are generally not aware that pesticides can affect non-target plants and animals, natural enemies, biodiversity in general, soil fertility, and consumer health; this alarming tendency was also observed in Vietnam (Houbraken et al., 2016). In general, positive correlations were found between them and the perception that pesticides can affect their environment area (table 4), but not in the case of the health of agricultural workers, as they do not understand that agricultural workers are part of the environment area, regardless of whether they received training or not. It was evident that farmers in our study had not received enough training before the survey was conducted. Limited training poses a challenge for the implementation of ecological and integrated pest management programs, since producers are the critical link in the production process and in the adoption of the programs.

About 82.5 % of the surveyed farmers believed that in the last five years, there had been a trend towards an increase in the use of pesticides. Reasons for this increase (use of the inadequate pesticide volumes, increase in pest resistance, increase in the pest population, and increase in budget) agree with the results found by other authors (Ngowi et al., 2007; Rosquete-Pérez, 2011). Similar to other studies, as can be observed in table 4, Cuban farmers considered that pesticides can enter the body through the skin, mouth, and nose (Kumari & Reddy, 2013; Leungo et al., 2012), but these can mainly affect their health if they are ingested (positive correlation); however, not when they come in contact with the skin or enter through the nose. While participants in our study were aware of specific health effects (e.g., nausea, dizziness, sneezing, skin problems, shortness of breath, coughing, and headache, observed in figure 2), the economic benefits achieved by using pesticides overpowered their concerns regarding the dangers, resulting in the adoption of risky practices. Other authors have noted similar behaviors (Lekei et al., 2014). Around 53 % of the participants claimed that they had suffered adverse effects at least once while working with pesticides. The specific effects suffered by Cuban farmers (e.g., dizziness, vomiting, nausea, headache, and sneezing) are observed in figure 2; these are similar to those reported by farmers in other regions of the world (Houbraken et al., 2016; Ngowi et al., 2007).

Some of the products stored within houses included pesticides classified as moderately hazardous. These include WHO Class I and II pesticides, such as bifenthrin, cypermethrin, methamidophos, fipronil, thiodicarb, thiacloprid, chlorfenapyr, and endosulfan. Endosulfan is an organochlorine pesticide banned in many countries due to its health and environmental concerns and has been included in the list of persistent organic pollutants (POPs) scheduled for elimination (UNEP/POPS/POPRC.5/10, 2009). Rapid capacity building and implementation of protective measures must be taken to protect human health and environmental integrity (Lekei et al., 2014; Varona-Uribe et al., 2012).

The backpack sprayers with which these products are applied were most often cleaned after each application. Some backpack sprayers are cleaned in the field. However, others are cleaned near drinking water wells used by the family, or near a water body located close to the cultivated field, posing a high risk to humans and the aquatic life, respectively. In addition to the above-mentioned active compounds, farmers also employ emamectin benzoate, acephate, deltamethrin, lambda-cyhalothrin, methomyl, beta-cyfluthrin, and malathion, all of which are classified with a toxicity level of 1 or 2 for fish and bees, representing an elevated and imminent risk to both aquatic and terrestrial wildlife (Sutherland, Horne, Weir, Russell & Oakeshott, 2004). Their use should, therefore, be minimized or prohibited.

Conclusions

Various sources of potential domestic and occupational pesticide exposure were obtained during the survey, even though the educational level of the farmers was generally high. Mostly, farmers are aware of the hazards of pesticides and acknowledge that pesticides can affect human and environmental health; however, they are not aware that the risks of exposure are high. The economic benefits achieved by the use of pesticides dominated their concerns regarding the danger of these. The lack of personal protection equipment, high frequency of spraying, lack of knowledge, and inability to understand the pesticide label, are the leading risk causes to workers, nearby residents, and the environment in general. By providing specific training to farmers and with the advice from regional authorities on the control and supply of more efficient, more effective, and less toxic products, it is possible to reduce the risks of adverse effects of pesticides on human and environmental health in Cuba.

Acknowledgments

The authors received no specific funding for this work. The authors want to thank the Provincial Delegation of Agriculture in the Province of Sancti Spíritus, and especially, the farmers and cooperatives visited during the realization of this study.

Disclaimer

All the authors made significant contributions to the document and agree to its publication; further, all the authors state that there are no conflicts of interest in this study.

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