Knowledge, Attitude and Practice of Pesticides use and Waste Disposal among Vegetable and Cotton Farmers in Bobo Dioulasso, Burkina Faso

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Abstract: ***The knowledge, attitude and practice of pesticides use and waste disposal among vegetable and cotton farmersin BoboDioulasso, Burkina Faso were surveyed using a structured questionnaire. Results showed that 32.1% to 60.3% of the farmers had poor educational background, while none had completed tertiary education (indicative of poor knowledge). Majority of farmers (69.4% to 99.3%) re-sprayed the treated fields until the spray tank was empty (indicative of poor practice). Some farmers either buried (35.9% to 64.3%) or burnt (30.7%) the empty pesticide containers in the field. Majority (74.6% to 95.1%) of the farmers consumed the contaminated water around the field or used it for other domestic purposes (indicative of poor attitude). Results obtained from this survey compels the need to take farmers' education as priority. Further, there is a need to encourage research into the development of simple environmentally-friendly methods, such as biobeds, to degrade pesticide residues in rinsate.***

Keywords: Developing countries, education, knowledge, pesticide containers, pesticide practice, rinsate

1. Introduction

The use of pesticides in agriculture contributes to increase in crop yields by suppressing weeds and controlling pests (Mansour, 2004). For example, Popp et al. (2013) reported that the increased use of pesticides nearly doubled food crop harvests from 42% of the theoretical worldwide yield in 1965 to 70% in 1990. Also, Oerke (2006) found that without pesticides, 70% of crop yields could have been lost to pests. Sheahan et al. (2017) have opined that other benefits of pesticides usage could include reduced cost of on-farm labor and inputs of other agrochemicals, improvedcrop performance and thus increased crop yield due to reduced crop-weed competition. Despite the benefits derived from their usage, pesticides and their degradation products can enter into the environment through runoffs or spray drifts (Raupach et al., 2001; Woods et al., 2001), thus posing a risk to aquatic organisms.Human beings may also be affected through the consumption of contaminated water, vegetables or animals. According to a UN report, the potential cost of pesticide-related illness in sub-Saharan Africa between 2005 and 2020 could reach $90bn (£56bn) (The Guardian, 2012). Further, the UN has estimated that more than 200,000 people die annually around the world because of pesticide exposures (Jeyaratnam, 1985; UN, 2017).

Poor farmers' education, inadequate training and awareness about pesticide use and disposal, insufficient information on hazards, and inadequate regulation,particularly in the developing countries, are major factors responsible for poor management and handling of pesticides, and thus theentry of pesticide residues into the environment (Sharafi et al., 2018). Recena and Caldas (2008) have opined that low educational levels of farmers also contribute to higher exposure to pesticides.

Pesticide wastes have been defined as any kind of useless material containing pesticide, such as surplus spray solutions, pesticide solutionleftover in the spray equipment, pesticide-contaminated water and materials produced after cleaning up spray equipment (rinsate), empty pesticide containers, and old pesticide products (Nesheim and Whitney, 1989). Disposal of pesticide wastes (liquid or solid) into nearby water bodies,burning or dumping of empty containers around the farm (Jones, 2014; Ntow et al., 2006; Oluwole and Cheke, 2009)are common poor practicesreported among farmers in the developing countries. Worse still, some farmers re-use the empty containers forstoringfood and drinking water (Coppola et al., 2007; Huici et al., 2017; Mengistie et al., 2016). After they have been used and emptied, if not rinsed properly, pesticide containers are considered hazardous due to residual pesticides retained in them (Buczynska and Szadkowska-Stanczyk, 2005; Elfvendahl et al., 2004; Huici et al., 2017; Ntow et al., 2006), and can cause damage to human healthand the environment.

The objective of this study was to determine farmers' knowledge and awareness regarding pesticides handling, as well as to assess their attitudes and practices regarding storage, handling and disposal of pesticides wastes. The study was carried out among vegetable and cotton farmers in regions of BoboDioulasso, Burkina Faso. Information obtained from this study and the general recommendation could be of relevance to farmers in the sub-Saharan African countries.

2. Material and methods

2.1 Study site and population

A survey was conducted among vegetables and cotton farmers in BoboDioulasso, Burkina Faso, in West Africa.The vegetable farms were from nine zones (Dogona, Ko-Deni, Leguema, Karangassosambla, Toukoro, Kunima, Diaradogou, Sabarydougou, and Lafiabougou) and the cotton farms were from three zones (Kuini, Denkiena and Dissankuy) of BoboDioulasso. In the study locations where farmers are in associations, we contacted the head of the association to mobilize the other farmers for the interview. The selection of farmers was on a voluntary basis. Generally, most of the vegetable farmers were small scale land-owners with farms less than 2 ha,while the cotton farmers own a maximum of 59 ha. Most of the vegetable and cotton farmers largely depend on synthetic pesticides to control pests, diseases, and weeds.

2.2 Data acquisition

There has not been a similar study in the country so far assessing farmers' knowledge, attitude and practice on the use of pesticides.Therefore the survey included farmers who do not have proper knowledge, attitude, and practice about pesticides use and waste (liquid and solid) disposal. A total of 184 vegetables farmers and 140 cotton farmers were interviewed individually. Data were collected by means of a structured questionnaire administered via personal interviews. This method was used because some of the respondents did not have formal education and many of those who had some education might not be familiar with the terminologies used in the questionnaire. The questionnaire contained three main sections. Thefirst part of the questionnaire included questions about the socio-demographic characteristics of the respondent farmers, such as age, educational level, etc. The second part included seven questions about pesticides and the use of it. A third part of the questionnaire contained the questions about Knowledge, Attitude, Practice (KAP) constructs. The questionnaire contained both fix-response and open-ended questions about common practices of farmers on disposal of pesticide waste after use. In particular, farmers were presented with a number of multiple-choice tests and were asked to choose the answer that they thought best described their attitude for each particular case. Besides closed questions, free space for alternative answers was also included in all questions. The questions and the possible alternative answers were read to interviewees by the interviewers who ticked the given answer(s). The interviews were conducted in a friendly wayand there was very good cooperation.To avoid any potential bias, the farmers were informed that the study was only for academic research only. All farmers who participated in the survey werefull-time farmers earning off their income mainly from agricultural activities.

2.3 Statistical Analysis

The raw data from the screening questionnaires were entered into specially designed databases (Sphinx Lexica V5). The frequencies of answers were calculated for each question. Relative frequencies were compared using the chi-square test to determine significantdifferences in the proportions of given answers. Mean differences were declared significant at the 95% confidence level.

3. Results

In the cotton producing areas, farmers' age was between 25 and 68 years, with an average of 43.8 and a standard deviation of 9.9 years (Table 1). The largest group of cotton farmers was within the age group of 41–50, followed by those within the age group of 31–40. The two groups together comprised 65.7% of the cotton farmerssurveyed. Average age of respondent vegetable farmers was 40.8 and a standard deviation of 11.6 years (Table 1). The largest group of respondent vegetable farmers was within the age group of 31–40, followed by those within the age group of 51–68. The two groups together comprised 55.9% of the vegetable farmers surveyed.

Table 1: Age of respondents

Cotton farmers			Vegetable farmers	
Age	No	%	No	%
18-30	10	7.1	43	23.4
31-40	42	30.0	55	29.9
41-50	50	35.7	36	19.6
51-68	37	26.4	48	26.0
Average	43.8		40.8	
Minimum	25		18	
Maximum	68		66	
SD	9.9		11.6	

A proportion of 32.1% of respondent cotton farmers and 60.3% of respondent vegetable farmers did not have a formal education (Table 2). 38.6% of cotton farmers and 6% of vegetable farmers have secondary education. Among the respondentvegetable and cotton farmers, none had completed tertiary education.

Table 2: Education of respondent

Education level	Cotton farmers		Vegetable farmers	
	No	%	No	%
None	45	32.1	111	60.3
Primary	41	29.3	49	26.6
Secondary	54	38.6	11	6.0
Tertiary	0	0.0	0	0.0
X^2	40.20		223.94	
p	≤ 0.001		≤ 0.001	

Majority of cotton (99.3%)and vegetable (69.4%) farmers reported that they re-sprayed the treated fields until the spray tank was empty (Table 3). However, some vegetables farmers reported that they stored the leftover solution for another application (14.7%), applied the leftover solution over a non-cropped area (6.0%) or applied the leftover solution to another crop listed on the label (3.8%).

Table 3: Farmers' attitudes on disposing of leftover pesticide spray solution

Main attitude	Cotton farmers		Vegetable farmers	
	No	%	No	%
I store the leftover solution for another application	1	0.7	27	14.7
I apply the leftover solution over a non-cropped area	0	0.0	11	6.0
I re-spray the treated field area until the tank is empty	139	99.3	72	69.4
I release the leftover solution to irrigation canals or streams	0	0.0	0	0.0
I apply the leftover solution to another crop listed on the label	0	0.0	7	3.8
X^2	688.09		170.62	
p	≤ 0.001		≤ 0.001	
Farmers were asked to choose only one statement, which best described their case.				

Among the cotton farmers, 64.3% reported that they collected and buried the empty pesticide containers, and 30.7% reported that they burned them (Table 4). Whereas, among the vegetable farmers, 35.9% reported that they buried the empty containers, and 30.4% reported that they burned them. Further, 16.4% of the cotton farmers and 8.2% of vegetable farmers reported dumping the empty pesticide containers by the field and using them for other purposes. Among the vegetable farmers, only 1.1% reported collecting the empty containers and selling them, but 2.7% reported dumping the empty containers into water bodies, and 16.3% reported dumping the empty containers with other wastes.

Table 4: Farmers' attitudes on disposing of empty pesticide containers

Main attitude	Cotton farmers		Vegetable farmers	
	No	%	No	%
I dump the empty containers by the field	23	16.4	15	8.2
I keep the empty containers for other uses	9	6.4	4	2.2
I collect the empty containers and sell them	0	0.0	2	1.1
I collect the empty containers and burn them	43	30.7	56	30.4
I dump the empty containers into water bodies	0	0.0	5	2.7
I collect the empty containers and bury them	90	64.3	66	35.9
I dump the empty containers with other wastes	0	0.0	30	16.3
Farmers were asked to choose only one statement, which best described their case				

After washing the application equipment, majority of cotton farmers (45.7%) reported applying therinsate over non-cropped area (Table 5). Almost similar population of cotton farmers reported reapplying the rinsate to the treated field (28.6%) or releasing it into pit made for rinsate collection (25.7%). Among the vegetable farmers, 42.9% reported reapplying the rinsate to already treated field. Almost similar population (35.3%) of farmers reported applying the rinsate on non-cropped areas. However, very few vegetable farmers reported releasing the rinsate into or near irrigation canals (6.5%) or into collection pit (8.2%).

Table 5: Farmers' attitudes on disposing of rinsates after washing the application equipment

Main attitude	Cotton farmers		Vegetable farmers	
	No	%	No	%
I apply the rinsates to the treated field	40	28.6	79	42.9
I apply the rinsates over a non-cropped area	64	45.7	65	35.3
I release the rinsates into or near irrigation canals or streams	0	0.0	12	6.5
I release it in pit make for rinsates water collect	36	25.7	15	8.2
Farmers were asked to choose only one statement, which best described their case				

Most cotton (95.1%) and vegetable (74.6%) farmers reported that they use water around the field for consumption and other domestic purposes (Table 6). 4.9% of cotton farmers and 25.4% of vegetable farmers stated that they do not use the water around the field except for irrigation.

Table 6: Farmers' attitudes on using water around the field

Main attitude	Cotton farmers		Vegetable farmers	
	No	%	No	%
Consumption and domestic use	133	95.1	138	74.6
No use	7	4.9	46	25.4

4. Discussion

4.1 Effect of farmers' age and educational levels on pesticide use and disposal

A survey was carried out to investigate the knowledge, attitude and practices of farmers about pesticide use and waste disposal strategies in the vegetable and cotton producing regions of BoboDioulasso, Burkina Faso. The result of socio-demographic characteristics of the farmers showed that older individuals went into cotton cultivation than younger individuals, and reverse was the case for vegetable cultivation. This could be because of the intricacies associated with cotton farming compared to vegetable farming. For example, cotton cultivation requires large area of land which may require conversion of customary or state land to privately titled land or land under long-term lease(Hall et al., 2017). However, most vegetable farms are established on lands thatdo not necessarily require such land transfer policies. This could be supported by the fact that majority of the vegetable farmers owned farmlands less than 2 ha, while the cotton farmers own a maximum of 59 ha. Also, Ojo (2008) has noted that the land tenure system in Africa is a major factor, among others, that seriously limits access to land for both small and large scale agricultural production.

The study showed that majority of the respondent cotton farmers had secondary education, as opposed to the vegetable farmers who largely did not have a formal education. The level of farmer's education will influence their ability to read and understand pesticide labels. In Iran and neighboring countries, improper handling and application of pesticides by farmers was attributed to theirno to little educational level (Sharafi et al., 2018; Yİlmaz, 2015). Farmer's knowledge of pesticide handling and application as well as risks is essential for improving safety in pesticide use (Mohanty et al., 2013; Wang et al., 2017). Farmers' knowledge about the potential risks associated with improper pesticide handling and disposal can be increased through adequate education and training (Schreinemachers et al., 2017).

4.2 Effect of farmers' attitudes on disposal of pesticide containers, rinsate and leftovers

Results of this survey showed that majority of respondent farmers bury empty pesticide containers on their field; while some farmers burn the empty containers. However, a very few farmers have indicated dumping the containers by their field. This clearly shows that none of the farmers followed an environmentally safe approach to disposing of the empty pesticide containers. Improper disposal of pesticide containers is common among farmers from developing countries. For example, farmers in the rural regions of Pieria in northern Greece were reported to either burn, bury or dump empty pesticide containers on their farms, while a larger number repeatedly used the same containers for spraying (Damalas et al., 2008). In Ghana, about 60% of vegetable farmers were reported to dispose of empty containers on the field, with evidence of containers littering the field (Ntow et al., 2006). Worse still, farmers in some developing countries have been reported to use empty pesticide containers to store food and drinking water (Huici et al., 2017; Mengistie et al., 2016). Coppola et al. (2007) also reported that about 77% of the respondent farmers from some regions of Ethiopia used the containers in various household contexts. After they have been used and emptied, if not rinsed properly, pesticide containers are still considered hazardous due to residual pesticides retained in them. Thus, when reused for storing food and water, may lead to food-poisoning, and those left in the environment will lead to the contamination of soil and/or underground water sources.

General lack of education, awareness and facilities for safe collection and disposal of empty pesticide containers could be reasons for farmers' reuse or improper disposal of empty pesticide containers (Damalas et al., 2008; Sharafi et al., 2018). Previous training on pesticide use has been associated with increased safety behavior among farmers, thus contributing to lower occupational exposure to pesticides (Bondori et al., 2018; Damalas and Koutroubas, 2017).Developed countries have strategies for collecting empty pesticide containers; whereas, such strategies are lacking in developing countries. For example, in 2003, France and Australia, both examples of developed countries, collected about 25% and 35%, respectively, of the total number of empty pesticide containers (Huici et al., 2017). Ecuador and Uruguay, examples of developing countries, managed to collect 0% and 4%, respectively, of the total number of empty containers generated in 2004. Jones (2014) has opined that the key to solving the problems associated with empty pesticide containersis to train farmers and to establish multi-stakeholder container management programs, which remove empty containers from the environment, re-process and recycle them into appropriate end uses. In 2014, a Bolivian non-governmental organization implemented a project which installed collection centers for empty pesticide containers where they collect, properly empty and secure the final disposal through actions such as the triple rinse (Huici et al., 2017).

Accidental or deliberate release of pesticide residues into the environment can harm humans as well as non-target organisms such as plants, soil microbes, beneficial insects, fish and other aquatic life (Damalas and Koutroubas, 2017). Although only a very few vegetable farmers disposed of their rinsate into/near irrigation canal or stream, these water sources, in most cases, also serve as source of drinking water for the farming community. Sharafi et al. (2018) reported thatabout 12% of the farmers released the rinsate into streams; while Damalas et al. (2008) reported that about 66% of farmers disposed of the rinsate in irrigation canals and streams. A little contamination from such deleterious chemicals into the water sources, which are potentially consumed, could result to health impairment of the entire community.

A significant number (about 28% to about 46%) of respondent farmers apply the rinsate to either non-cropped or already treated field. Over-application of pesticides to the same field have been reported particularly among farmers in developing countries. For example, vegetable farmers in Bangladesh were reported to applypesticides at concentrations higher than recommended (Akter et al., 2018). Similarly, Ngowi et al. (2007)and Nguyen et al. (2018)also reported that about 40% to 50% of vegetable farmers interviewedin Ghana and Vietnam, respectively, applied pesticides more than 5 to 7 times in one cropping season. With the most careful pesticide application, spray drift to off-target areas is inevitable. Over-application or re-applying leftovers or rinsate could pose more detrimental effect by increasing the amount of pesticide residues that will drift into non-target areas, or be absorbed into the soil (Raupach et al., 2001; Woods et al., 2001). Also, excessive application of pesticides may lead to high pesticide residues retained on the plant, which may be dangerous to farmers and vegetable/fruit consumers (Nguyen et al., 2018).

Damalas and Koutroubas (2018)have opined that the best way to manage pesticide leftovers is to plan and use just the amount of product needed, thus reducingleftovers that could later create an ecological menace (Whitford et al., 2006). A training program on proper disposal of rinsate waste is also required for farmers to prevent future occurrence of such behavior. A more environmentally-friendly means of removing pesticide residuesfrom the environment is by employing the use of a *biobed*. Biobed, originally designed in Sweden, was intended to collect and degrade pesticides arising from filling operations, pesticide wastes, spray tank leftovers and wash residues (Torstensson and Castillo, 1997). The biobed comprises of a biomixture of straw, peat and soil in a 2:1:1 ratio (Torstensson and Castillo, 1997). *Straw* is the main component for ligninolytic fungal growth; the *peat* contributes to the sorption capacity and helps to regulate moisture in the biomixture; the*soil* provides the site for pesticide sorption and favors microbial activity (Castillo and Torstensson, 2008; Torstensson and Castillo, 1997). Several studies have demonstrated that this biological system can effectively retain and degrade a wide variety of pesticides (Castillo and Torstensson, 2008; Coppola et al., 2007; Tortella et al., 2012; Vischetti et al., 2006). However, the biobed is a technology that has not been tested in many developing countries.

5. Conclusion

The present study provides an overview of the knowledge, attitude and practices on pesticide use and waste disposal strategies common among vegetable and cotton farmers in developing countries, using Burkina Faso as a case study. The information provided was based solely on information obtained from the farmers. The results indicated that none of the farmers followed an environmentally safe approach to disposing of the empty pesticide containers and rinsate. Incorrect and high-risk methods for handling and disposal of pesticide containers and rinsate could be attributed to farmers' lack or poor level of education and awareness, particularly among vegetable farmers. This necessitates the need to take farmers' education as priority. Knowledge of farmers' attitudes towards disposal of pesticide waste (empty containers, rinsate and leftovers) can be important to finding out critical points of intervention to promote safety during pesticide handling.Further, there is a need for stake-holders and government bodies in the developing countries to encourage research into on-farm use of biobed in order to reduce pesticide-induced environmental hazards.

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