Journal of Experimental Biology and Agricultural Sciences

<http://www.jebas.org>

ISSN No. 2320 – 8694

CHARACTERIZATION OF PESTICIDES AND PRACTICES OF COTTON PRODUCERS AND PESTICIDES SELLERS IN THE COTTON ZONE OF BALA'S HIPPOPOTAMUS POND BIOSPHERE OF BURKINA FASO

Bazoma BAYILI^{1,2*}, Richard OUEDRAOGO^{3,4}, Sylvain ILBOUDO^{4,5}, Lamine POODA²,
Macaire BONKOUNGOU², Jean Fidèle BATIONO⁶, Jean Bosco OUEDRAOGO¹,
Georges Anicet OUEDRAOGO²

¹Institute of Health Sciences Research, Regional office (IRSS-DRO/CNRST), Bobo Dioulasso, Burkina Faso

²University of Nazi Boni (UNB), Bobo Dioulasso, Burkina Faso

³Agricultural Institute of Environment and Agricultural Research, Regional office (INERA-DRO/ CNRST), Bobo Dioulasso, Burkina Faso

⁴Joint International Research – Environment, Health and Society Unit (UMI 3189, ESS) CNRST/CNRS/UCAD/UGB/USTTB

⁵Institute of Health Sciences Research, Bobo Dioulasso, Burkina Faso; (IRSS/CNRST), Ouagadougou, Burkina Faso

⁶Muraz Center, Bobo-Dioulasso, Burkina Faso

Received – October 11, 2019; Revision – November 21, 2019; Accepted – December 22, 2019

Available Online – December 25, 2019

DOI: [http://dx.doi.org/10.18006/2019.7\(6\).554.568](http://dx.doi.org/10.18006/2019.7(6).554.568)

KEYWORDS

Cotton

Pesticides

Practices

Producers

Retailers

Bala's hippopotamus pond
biosphere

Burkina Faso

ABSTRACT

Chemical pesticides are systematically used against pests in conventional cotton growing. However, their use is known to be associated with health and environmental risks. Current study aimed to characterize pesticides and both crop producers and pesticide retailers practices. To this end, a survey and documentary research were carried out in the cotton zone around the biosphere of the Bala's hippopotamus pond, Burkina Faso. The results of study revealed that 87.5% of the pesticides retailers do not have agreement for pesticides selling. Further, more than 95% of the farmers wear their usual rural outfits to apply pesticides and 60.4% of them are not educated. The re-entry time into the treated fields was at most 24 hours for the majority of producers. Empty packaging is incinerated, abandoned in the wild or reused. About 50% of the producers experienced acute pesticide poisoning. The pesticide supply chain involves major distributors, retailers and pesticide users. Except LADABA, the 27 pesticides encountered at the producers, were identified at the retailers. Most of the used pesticides are mainly class III. In addition, 34.15% and 14.81% of pesticides from retailers and cotton producers are not

* Corresponding author

E-mail: bbazoma@yahoo.fr (Bazoma BAYILI)

Peer review under responsibility of Journal of Experimental Biology and Agricultural Sciences.

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allowed for use by the Sahelian Pesticides Committee (CSP). Some of these pesticides were composed of banned active substances (endosulfan, atrazine and paraquat). Of the products used, imidacloprid, paraquat and spirotetramate are CMR active substances; deltamethrin and flubendiamide are endocrine disruptors. The regulation and continuous promotion of good practices for the use of pesticides approved from less toxic active substances should be favored in order to protect health and the environment.

1 Introduction

In Burkina Faso, cotton farming accounts for an average of 65% of households' cash income and contributes around 4% to national GDP and more than 28% to the country's agricultural GDP (MECV, 2011). However, cotton crop is confronted with the strong attacks of numerous pests including *Helicoverpa armigera* (Hübner) (Lepidoptera - Noctuidae), *Diparopsis watersi* (Rothchild) (Lepidoptera - Noctuidae), *Earias spp.* (Lepidoptera - Noctuidae), greenfly *Aphis gossypii* (Glover) (Homoptera - Aphididae) and defoliating caterpillars including *Haritalodes derogata* (Fabricius) (Lepidoptera, Pyralidae) (Achaleke & Brévault, 2010; Badiane et al., 2015). The high pest pressure causes huge cotton crops losses which reached up to 70% of total yields (Traoré, 2008). To cope up with these losses farmers used pesticides for seed (insecticides and fungicides), soil (herbicides, nematocides and fungicides), and foliar treatments (insecticides, herbicides and fungicides) (Ouédraogo et al., 2011; FAO, 2015). In 2009, the proportion of global pesticide sales for cotton was 6.2%, compared to 29.7% for fruits and vegetables, 17% for cereals, 9.6% for soybean and 9.3% for maize (FAO, 2015). While in case of Burkina Faso, among the used pesticides, 90% of the pesticides are used in cotton production (PAN UK, 2018). Several pesticide formulations have been identified in Burkina Faso in the cotton zone. The main chemical groups of pesticides which used in cotton growing areas of Burkina Faso are Neonicotinoids, Pyrethroids and Organophosphorus (Badiane et al., 2015). As per survey conducted in 2015, total 216 pesticide formulations was identified from the main cotton production area of the country, but 52% of these pesticides were not authorized by the current registration system (Convention de Rotterdam, 2016).

As per the nature, physicochemical, biochemical and toxicological properties of pesticides, these can lead to major risks for human health (Saravi & Shokrzadeh, 2011) and environment (Calvet et al., 2005). In addition, genetically modified cotton was introduced in Burkina Faso about ten years ago (2008-2016) (Sawadogo, 2016). Its abandonment marks the return to the intensive conventional culture whose multiplicity of treatments could induce a high level of human and environmental exposure.

Like most CILSS countries, the control and management of agricultural pesticides in Burkina Faso is governed by LAW N°

026-2017/AN (Assemblée Nationale, 2017). This law refers in particular to the strict conditions of distribution and sale of pesticides on the national market and advocates that employment in farming must be done according to good agricultural practices. Despite these legal management mechanisms, studies have shown that the distribution and supply chain of pesticides to producers remains partly fraudulent (Sory, 2011; Son et al., 2017). In addition, pesticide distribution practices would influence the conditions of their use by producers at the local level, and have an impact on human health and the environment. Proposed study is a part of global approach of risk analysis related to pesticides used in agriculture, based on an understanding of the practices of crop producers and sellers in the rural areas around the biosphere of the Bala's hippopotamus pond in Burkina Faso.

2 Materials and Methods

2.1 Study framework and study population

The study was conducted at the biosphere of the Bala's hippopotamus pond located in southwestern Burkina Faso about 60 km from Bobo-Dioulasso. Belem (2008) raised the risk of environmental degradation due to the high anthropization. Eco-chemical risks associated with contamination of the pond by pesticides used on the watershed have also been suspected (Soleri, 2013). Indeed, the Satiri is an important cotton region of SOFITEX, involving the circulation and massive use of various pesticides. Thus, the pesticide dealers of Kadomba, Satiri, Bala and Tiarakô villages are attended in current study (Figure 1). All pesticide dealers encountered in the village markets were included in the study with their consent. While the cotton producers of the Tiarako, Sokourani and Bala villages, who have continuously produced cotton from last 3 seasons, including the 2018-2019 campaign, were sampled. The sample of producers was formed on the basis of 20 associations of 513 cotton producers, of which 139 producers were randomly selected. A minimum sample size of 82 producers was determined according to Rea & Parker (2014) from the following formula:

$$n = \frac{Z_a^2 \times [p(1-p)]N}{Z_a^2 \times [p(1-p)] + (N-1)ME_p^2}$$

where N stands for population size, $[ME]_{p^2}$ for sampling error (10%), p for the true proportion set as 0.5 and Z_a is equal to 1.96 for 95% confidence level.

Figure 1 Geographical location of the study site

2.2 Surveys

Cross-sectional surveys based on personal interviews were conducted from 1 June to 15 September 2018 with pesticides retailers while in case of cotton producers survey was conducted from 25 September to 10 October 2018. An individual semi-structured questionnaire was designed and administered in the form of a semi-structured interview to 8 retailers and sampled producers.

For retailers, field trips have been planned to list all products used during the campaign. The information collected from the socio-professional characteristics of the cotton producers and pesticides retailers, the commercial pesticide specialties, the marketing / use mode, the pesticide supply system, etc. Also, the questionnaire administered to cotton producers included a section on reported cases of poisoning.

2.3 Characterization of pesticides

The characterization of pesticides was made for commercial specialties and active substances by documentary research. Thus, the positive global list of pesticides approved by the Sahelian Committee for Pesticides (CSP) was used to know in particular the registration status and the use of pesticides. WHO Recommended Classification of Pesticides by Hazard (WHO, 2010) used to

determine “WHO toxicity class” of pesticides, is given in table 1. Carcinogenic, mutagenic and reprotoxic (CMR) and endocrine disruptor status of the pesticide active substances inventoried were determined from the Pesticide / Biopesticide Properties Database (PPDB / BPDB).

Table 1 WHO Recommended Classification of Pesticides by Hazard

WHO Class	Category	LD ₅₀ for the rat (mg/kg body weight)	
		Oral	Dermal
Ia	Extremely hazardous	< 5	< 50
Ib	Highly hazardous	5–50	50–200
II	Moderately hazardous	50–2000	200–2000
III	Slightly hazardous	Over 2000	Over 2000
U	Unlikely to present acute hazard	5000 or higher	

Table information source: WHO (2010)

2.4 Data analysis

The pesticide characteristic data and the distributor survey data were manually processed before being entered and analyzed with Excel 2013 software. Further producers' practices were analyzed with SPSS v20 software. Descriptive statistics focused on simple

frequencies and averages. Producer practices were analyzed by comparison with good agricultural and phytosanitary practices published in the International Code of Conduct for the Distribution and Use of Pesticides (FAO/OMS, 2014).

3 Results

3.1 Sociodemographic Characteristics

The pesticide retailers encountered (8 in total) were male with an average of 6 years in the sale of pesticides. Among the studied retailers, only one had an approval for pesticides sale. In addition, 87.5% of retailers had no knowledge of the CSP and 75% did not have any updated list of products approved by the CSP. Further, only one had safety data sheets in his store and a first aid kit containing medication. In case of producer, all crop producers were male with an average age of 39 years old. Among these, the youngest one is 18 years old and the oldest one is 60 years old. In case of educational status, 60.4% of the sellers were illiterate, 23% had education only up to primary school level while 16.5% had secondary school level education. Almost half of the producers (45.3%) had more than 20 years of pesticide used experience (Figure 2).

3.2 Pesticide supply sources

Pesticide distributors generally obtained their supplies from whole sellers and phytopharmaceutical companies (such as SOLEVO, Saphyto, BaryAgrochem, Prophyma, Senefura, Af-chem, GNESSIN Establishment) in Bobo-Dioulasso. Cotton producers obtain almost all pesticides from retailers in local markets and insecticides from SOFITEX (Table 2).

3.3 Cotton producers and pesticides retailers training level

Thirty seven percent (37.5%) of the retailers received training on the safe management of pesticides, provided by the International Fertilizer Development Center (IFDC), Plant Protection and Packaging Direction (DPVC), the Agricultural Inputs Wholesalers and Retailers Association of Burkina Faso (AGRODIA), African Society of Phytosanitary Products and Insecticides (SAPHYTO) and SOLEVO. As for cotton producers, 69.6% received training on a various set of themes related to the pesticides use (Figure 3).

3.4 Sale of pesticides

Among the studied seller respondents, 50% retailers are associated with the selling of food and other consumer products such as corn, coffee, rice along with the pesticides in the same shop. Two surveyed retailers said producers returned to them purchased pesticides. All retailers gave on choice information regarding the risks and use of pesticides to the producers. No seller was selling Personal Protective Equipment (PPE).

Figure 2 Producers' experience in cotton production (The bars corresponded to the standard error which represents mean $\pm$ SE)

Figure 3 Various training taken by crop producers' during pesticides handling

Table 2 pesticides supply sources of cotton producers

Sources Types	SOFITEX			Local markets			Bobo Market			SAPHYTO			UNPCB		
	I	H	F	I	H	F	I	H	F	I	H	F	I	H	F
Effective	139	65	12	0	118	0	0	12	0	0	3	0	0	2	0
Frequency (%)	100	46.76	8.63	0	84.89	0	0	8.63	0	0	2.16	0	0	1.44	0

I : insecticide ; H : herbicide ; F : fungicide

3.5 Use and management modes of pesticides

The choice of pesticides to be used is made by 63.3% of the cotton producers themselves but some time it depends on the choice of technical services providers (59.4%) to the producers (Figure 4). Producers are rarely on the use of conventional PPE in pesticide treatment operations (Figure 5). Almost all producers (95.7%) used their usual field clothing during treatment sessions and rarely (2.2%) they use suitable suits made for pesticides application (Figure 6). Also, 27.5% of the producers used combination of certain pesticides to treat crops.

After the use of pesticides, several methods of used packaging materials management are adopted by the producers (Figure 7). They went through incineration (43.9% of producers), desertion in nature (42.8%) and even in domestic use (5.1%) (Figure 8). Several re-entry times are observed by producers, with approximately 70% waiting no more than 24 hours (Figure 9). Most producers

Figure 4 Various criteria for pesticides choosing by producers

Figure 5 Precautions taken by crop producers during pesticides handlings

Figure 6 Different protection equipment used by crop producers during pesticides handlings

Figure 7 Management mode of empty packaging after treatment

Figure 8 (a) Empty packaging for incineration; (b) Empty packaging in a dwelling; (c) Abandoned packaging at the edge of a well

have water points (well, ravine, river, ponds) in their field or nearby, and they use this water for different purposes. Thus, 65.1% use them for drinking, 33.6% for pesticide processing activities, 29.9% for domestic use and 20.4% for watering domestic animals (Figure 10). Most of the producer used these water sources for prepared stock solution of pesticides and there is a great chance of spreading contamination during operation or handling these pesticides.

3.6 Cases of poisoning reported by producers

About half of the producers (49.64%) affirmed that they have felt signs of poisoning a few moments after pesticide application operations (Figure 11). During survey most common symptoms of pesticide poisoning faced by producers are itchiness (25.5%), eye burns (18.0%), dizziness (5.8%), various irritations (5.0%), skin irritations and headaches (3.6%), fever (2.2%) and stomach pain (0.7%).

3.7 Recommendations and suggestions from producers

Producers made recommendations / suggestions for their capacity building (32.1%), the reduction of the number of pesticides treatment (26.4%), accessibility to medical visits after treatment (24.8%), the availability and accessibility of PPE (21.7%), the reduction of the pesticide prices (13.3%) and the control of the pesticides sale (3.1%) (Figure 12).

3.8 Main identified pesticides

Eighty-three (83) commercial specialties based on 40 active substances were identified at retailers' (levels) during the campaign and 27 commercial specialties consisting of 20 active substances were identified at producers', among these 26 are identical to those found at retailers' levels. Of the identified pesticides from producers in particular, 77.78% were herbicides, 18.52% insecticides and

Figure 9 Reentry times in the field after treatment

Figure 10 Different uses of the existing water point in the field

Figure 11 Different signs of intoxication felt by crop producers during pesticide application

Figure 12 Recommendations related pesticides handling given by crop producers

Figure 13 Proportion of each type of pesticide (a) in markets and (b) from producers

3.70% fungicides (Figures 13a and 13b). The only product exclusively found among producers is KALACH. Glyphosate, nicosulfuron and paraquat are the active ingredient in most commonly used herbicide found at distributors', while at producers' these are glyphosate, diuron, haloxyfop-p-methyl, nicosulfuron and paraquat. Unregistered products accounted for 34.15% of the pesticides found in pesticides retailers (Figure 13a), including substances such as atrazine, endosulfan and paraquat.

For producers, these products accounted for 14.81% and also were composed of paraquat (Figure 13b). THUNDER, an insecticide which has been identified in retail stores, is an approved binary product containing Class Ib beta-cyfluthrin. All of the pesticides identified from producers and their characteristics are recorded in Table 3. Pesticides incriminated by producers as causing poisoning are mainly, PYRINEX QUICK 424EC (deltamethrin and chlorpyrifos-ethyl) (25.9%), TIHAN 175 O-TEQ (Spirotetremate

Table 3 List of pesticides encountered from retailers and producers

Commercial formulation	Type of pesticide	WHO class	CSP registration status	Active substances (a.s.)	Group of substances	WHO class of a.s.
*ACERO 84 EC ³	I	II	Yes	Isoclast (sulfoxaflor)	Sulfoximine	III
				Lambda-cyhalothrin	Pyrethroid	II
*ACTION 80 DF	H	III	Yes	Diuron	Phenylamide	III
*ADWUMA WURA	H	U	No	Glyphosate	Phosphonoglycine	III
ALLIGATOR	H	III	Yes	Pendimethalin	Dinitroaniline	II
ATRAHERB WP	H	II	No	Atrazine	Triazine	III
ATRAZILA 80 WP	H	II	No	Atrazine	Triazine	III
ATRAZILA 500 SC	H	II	No	Atrazine	Triazine	III
ATTAKAN C 344 SC	I	II	Yes	Imidacloprid	Neonicotinoid	II
				Cypermethrin	Pyrethroid	II
*AVAUNT 150 EC ¹	I	III	Yes	Indoxacarb	Oxadiazine	II
BACCARA	H	II	Yes	2,4-D	Aryloxyacide	II
				Propanyl	Anilide	II
BENAXONE SUPER 200 SL	H	II	No	Paraquat	Bipyridylum	II
BENAXONE SUPER 276 SL	H	II	No	Paraquat	Bipyridylum	II
BINBEFLA PLUS 720 SL	H	III	Yes	2,4-D amine salt	Aryloxyacide	II
BONNICO	H	III	No	Nicosulfuron	sulfonylurea	U
BONQUAT	H	II	No	Paraquat	Bipyridylum	II
CAIMAN ROUGE	I	II	No	Endosulfan	Organochlorine	II
				Thiram	Carbamate	II
CAIMAN ROUGE P	I	II	Yes	Permethrin	Pyrethroid	II
				Thirame	Carbamate	II
CALTHIO E	F	II	No	Endosulfan	Organochlorine	II
				thiram	Carbamate	II
CALTHIO MIX 485 WS	F	II	Yes	Imidacloprid	Neonicotinoid	II
				Thiram	Carbamate	II
				Metalaxyl	Phenylamide	II
CORAGEN 20 SC	H	U	Yes	chlorantraniliprole	Diamide anthranilique	U
CORIGNENA 500 EC	H	III	Yes	Terbutryn	Triazine	III
				metolachlor	Chloroacetamide	III
DEKADE PLUS 720 SL	H	III	Yes	2,4-D amine salt	Aryloxyacide	II
*DIGA-FAGALAN 360 SL	H	III	Yes	glyphosate	Phosphonoglycin	III
*DIURALM 80 WG	H	III	Yes	Diuron	Phenylamide	III
DIURON PLUS	H	III	No	Diuron	Phenylamide	III

Commercial formulation	Type of pesticide	WHO class	CSP registration status	Active substances (a.s.)	Group of substances	WHO class of a.s.
*EMAPYR ³	I	III	Yes	Emamectin benzoate	Derived from microorganisms	II
				Pyriproxyfen	Pyridine derived	U
*GALLANT SUPER	H	III	Yes	Haloxypop-p-methyl	Aryloxyphenoxypropionate	II
GENERAL	F	II	No	Endosulfan	Organochlorine	II
				Thiram	Carbamate	II
*GLYCEL 410 SL	H	II	Yes	Glyphosate	Phosphonoglycin	III
GLYCOT 700 SG	H	III	No	Glyphosate, isopropylaminesalt	Phosphonoglycin	III
*GLYPHADER 75 SG	H	III	Yes	Glyphosate	Phosphonoglycin	III
*GLYPHADER 360 SL	H	U	Yes	Glyphosate	Phosphonoglycin	III
GLYPHADER 68 SG	H	III	No	Glyphosate	Phosphonoglycin	III
GLYPHALM 360 SL	H	III	Yes	Glyphosate	Phosphonoglycin	III
*GLYPHE	H	U	Yes	Glyphosate	Phosphonoglycin	III
*GLYPHOBAR 480 SL	H	III	Yes	Glyphosate, isopropylaminesalt	Phosphonoglycin	III
GLYSTAR 360 SL	H	III	Yes	Glyphosate	Phosphonoglycin	III
*GRAMOSHAP SUPER	H	II	No	Paraquatdichloride	Quaternary ammonium compound	II
HALODAF 108 EC	H	III	Yes	Haloxypop-p-methyl	Aryloxyphenoxypropionate	II
*HALONET 104 EC	H	III	Yes	Haloxypop-p-methyl	Aryloxyphenoxypropionate	II
HERBEXTRA 720 SL	H	II	Yes	2,4-D amine salt	Aryloxyacide	II
HERBIMAS 240 OF	H	III	Yes	Dicamba	Benzoic acid	II
				Nicosulfuron	Sulfonylurea	U
IKOKADIGNE	H	II	Yes	Haloxypop-p-methyl	Aryloxyphenoxypropionate	II
*IMIDALM-T 450 WS	F	II	Yes	Imidacloprid	Neonicotinoid	II
				Thiram	Carbamate	II
INDOXAN	I	III	Yes	Indoxacarb	Oxadiazine	II
KABABIN 40 SC	H	III	Yes	Nicosulfuron	sulfonylurea	U
**KALACH 360 SL	H	III	Yes	Glyphosate	Phosphonoglycin	III
*KILLER 450 SL	H	U	Yes	Glyphosate	Phosphonoglycin	III
*LADABA	H	U	No	Glyphosate	Phosphonoglycin	III
*LAMACHETTE 360 SL	H	III	Yes	Glyphosate	Phosphonoglycin	III
LAMBDA POWER	I	II	No	Lambda-Cyhalothrin	Pyrethroid	II
LAMBDRAP SUPER 2,5 EC	I	II	Yes	Lambda-cyhalothrin	Pyrethroid	II
LAMBDAQUEST 62 EC	I	II	No	acetamiprid	Neonicotinoid	II
				Lambda-cyhalothrin	Pyrethroid	II

Commercial formulation	Type of pesticide	WHO class	CSP registration status	Active substances (a.s.)	Group of substances	WHO class of a.s.
*LIBERATOR 500 SC	H	III	Yes	Diflufenican	Carboxamide	III
				Flufenacet	Oxyacetamide	II
MAIA 75 WG	H	III	Yes	Nicosulfuron	Sulfonylurea	U
MALIK 108 EC	H	III	Yes	Haloxypop-p-methyl	Aryloxyphenoxypropionate	II
MEPRODAP 510 EC	H	III	Yes	metolachlor	Chloroacetamide	III
				Promethryn	Triazine	III
MOMTAZ 45 WS	F	III	Yes	Imidacloprid	Neonicotinoid	II
				Thiram	Carbamate	II
NICOBAC	H	U	No	Nicosulfuron	Sulfonylurea	U
NICODAF 40 SC	H	III	Yes	Nicosulfuron	Sulfonylurea	U
NICOLABAN 40 SC	H	III	Yes	Nicosulfuron	Sulfonylurea	U
*NICOMAS 40 SC	H	III	Yes	Nicosulfuron	Sulfonylurea	U
NICONET 40 SC	H	III	Yes	Nicosulfuron	Sulfonylurea	U
NICOPAR SUPER	H	U	No	Nicosulfuron	Sulfonylurea	U
NICOPAT SUPER 40 OD	H	II	No	Nicosulfuron	Sulfonylurea	U
NICOPLUS 40 OD	H	III	No	Nicosulfuron	Sulfonylurea	U
ONYX 360 EC	H	III	No	S-metolachlor	Chloroacetamide	III
PINGRAZONE	H	U	No	Paraquatchloride	Quaternary ammonium compound	II
POLYTRINE C 186 EC	I	II	No	Cypermethrin	Pyrethroid	II
				Profenofos	Organophosphate	II
*POWER	H	III	Yes	Diuron		III
*PYRINEXQUICK 424 EC ²	I	II	Yes	Deltamethrin	Pyrethroid	II
				Chlorpyrifos-ethyl	Organophosphate	III
*ROUNDUP 360 XL	H	III	Yes	Glyphosate	Phosphonoglycin	III
RUBIS 100 SC	H	III	Yes	Bispyribac-sodium	Pyrimidinylcarboxy compound	III
SAMORY	H	III	Yes	BensulfuronMethyl	Sulfonylurea	U
*SEGAIBANA 40 SC	H	U	Yes	Nicosulfuron	Sulfonylurea	U
SUNHALOTHRINE 2,5% EC	I	III	Yes	Lambda-cyhalothrin	Pyrethroid	II
SUN-LAMBDA 2,5 EC	I	II	No	Lambda-cyhalothrin	Pyrethroid	II
SUNPHOSATE 360 SL	H	II	Yes	Glyphosate	Phosphonoglycin	III
SUPRAXONE	H	II	No	Paraquat	Bipyridylum	II
THUNDER 45 O-TEQ	I	II	Yes	Imidacloprid	Neonicotinoid	II
				Beta-cyfluthrin	Pyrethroid	Ib

Commercial formulation	Type of pesticide	WHO class	CSP registration status	Active substances (a.s.)	Group of substances	WHO class of a.s.
*TIHAN175 O-TEQ	I	III	Yes	Spirotetremate	Tetramicacid	III
				Flubendiamide	Benzene-dicarboxamide	III
TOPEXTRA 720 SL	H	II	Yes	2,4 D-Amine salt	Aryloxyacide	II
TRAZINE 500 SC	H	II	No	Atrazine	Triazine	III

I: insecticide; H: herbicide; F: fungicide * Pesticides common to producers and retailers; **Pesticide encountered from producers exclusively; ¹ Insecticide supplied by SOFITEX in first treatment window; ² Insecticide supplied by SOFITEX in 2nd treatment window; ³ Insecticide supplied by SOFITEX in 3rd treatment window

and Flubendiamide) and ACERO 84EC (Isoclast and Lambda-cyhalothrin) (11.5%), EMAPYR (Emamectin benzoate, Pyriproxyfen) (2.9%), LADABA (glyphosate) (1.4%) and GLYPHADER (glyphosate) (0.7%).

3.9 WHO toxicity class

The pesticides used by the producers are belongs to different classes of WHO toxicity, among identified pesticides 59.26%, 22.22% and 18.52% are belongs to Class III, U and II respectively. In case of active substances, these are at 50.00%, 40% and 10% to class II, class III and class U respectively.

3.10 CMR toxicity and endocrine disruptors

The pesticide found with producers contains 3 active substances (imidacloprid, paraquat and spirotetramate) with CMR effects. From the active substances that are not CMR, 29% are possible carcinogens and 65% are possible reprotoxic, among which, thiram is both possible carcinogenic, reprotoxic and mutagenic. Deltamethrin and flubendiamide, also used in approved formulations, are endocrine disruptors. CMR and endocrine disruptors' information collected from Footprint PPDB are recorded in Table 4.

4 Discussion

4.1 Surveys

Around the RBMH, the pesticides are the subject of an unauthorized trade in general by the retailers, thus posing the problem of their control and distribution. A study conducted in 3 regions of western Burkina Faso also reported 97% of

Table 4 Interpretation of CMR category and endocrine disruptor of the active substances of used pesticides (Footprint PPDB, 2018)

Actives substances	Carcinogenicity	Mutagenicity	Toxic for reproduction	Endocrine disruption
	Interpretation	Interpretation	Interpretation	Interpretation
Chlorpyrifos-éthyl	No	No	No data	Possibly
Deltaméthrine	No	No	Possibly	Yes
Diflufenican	No	No	Possibly	No data
Diuron	Possibly	No	Possibly	Possibly
Emamectine benzoate	No	No	Possibly	No data
Flubendiamide	No	No	Possibly	Yes
Flufenacet	No	No	Possibly	No data
Glyphosate acide	Possibly	No	No	Possibly
Glyphosate seld'isopropylamine	Possibly	No	No	No
Haloxypof-R-Méthyle	No	No data	No	No data
Imidaclopride	No	Possibly	Yes	No data
Indoxacarbe	No	No	Possibly	Possibly
Isoclast (sulfoxaflor)	Possibly	No data	Possibly	No data
Lambda-Cyhalothrine	No	No	Possibly	No
Nicosulfuron	No	No	No data	No data
Paraquat	Possibly	yes	Possibly	No
Paraquat dichloride	No	No data	Possibly	No
Pyriproxyfène	No	No	No	Possibly
Spirotetramate	No	No	Yes	No
Thirame	Possibly	Possibly	Possibly	Possibly

illegal retailers (Rotterdam Convention, 2016). Indeed, the supervision of the pesticides sale in Burkina Faso is governed under the Article 9 of the Law N° 026-2017/AN on pesticides, this article stipulating that the activity must be authorized by an approval issued by the Ministry of Commerce (Assemblée Nationale, 2017). Also, low level of education of crop producers does not allow them to interpret the instructions of the packaging labels and meaning of pictograms (Fayomi et al., 1998; Ouédraogo et al., 2009; Belhadi et al., 2016). In addition, the long experience of pesticides use, age of producers and low level of PPE use, presage chronic risks. It is also evident that producers and retailers have close trading relationships related to the marketing and supply of pesticides (Khooharo et al., 2008). Further, Fan et al. (2015) recognize that in some cases, retailers are the only ones who provide information to producers but in maximum cases these retailers have low level of formal education. This type of relationship between illegal and less educated cotton producers and pesticide retailers, could lead to the distribution and use of pesticides harmful to health and environment. In addition, the major problem related to the production of cotton is the attack of insect pests that cause enormous damage on cotton. Thus, the choice of insecticides must base on products popularized by research. Factors such as poverty lead them to buy most of the credit products payable by deducting the gain from the sale of cotton at the end of the season (Sawadogo, 2016; Luna, 2019). In addition, a practice of associating the sale of pesticides with consumer products is also dangerous for health knowing that leakage of pesticides from packaging can occur and contaminate food products. This can be a source of intoxication for consumers.

Around the RBMH, surveys have shown that most of the producers use their ordinary country outfits, far from the standard of conventional PPE, adapted to the types and nature of pesticides. However, the use of PPE is recommended to prevent exposure and the risk of pesticide applicators becoming intoxicated (Hanshi, 2001; Khan et al., 2009; Norkaew et al., 2010; Yuantari et al., 2015). Cotton producers partly noted the unavailability, cost and discomfort of the combinations. The discomfort related to the wearing of the suits would partly be due to the climate which is warm during the campaign (Weng & Black, 2015). Under this warm climatic condition, recommended clothes for pesticides spray might prevent the evaporation of sweating and affect different physiological mechanisms of central temperature regulation (Garrigou et al., 2008). This would create new hazards and health risk related to heat work. In addition, half of the producers reported cases of acute intoxication linked to certain pesticides including insecticides and glyphosate, confirming the same trend obtained during a study in western Burkina Faso in 2010 (Toé et al., 2013).

Some cotton producers mix pesticides before the treatments, which they believe will save time and efficiency. This practice should be

banned because it might given the existence of possible health and environmental effects linked to chemical mixtures (Bull et al., 2006; Youness, 2013; Décosse, 2013). Use of empty packaging in incineration, abandonment in nature and domestic purpose was reported during the study, these findings are in agreement with the observation of Nonga et al. (2011); Gomgnimbou et al. (2009); Ouédraogo et al. (2009) and Devez (2004). The proper management of empty packaging is must and it should be regulated by law.

Observation of the reentry time is crucial to avoid the risk of post-treatment intoxication. In Burkina Faso, field work involves several age groups and both sexes, among these, children and women are more sensitive to the effects of pesticides. Few producers unfortunately observe a post-treatment safety delay of at least 48 hours, the minimum time often recommended when using moderately hazardous pesticides (Samuel, 2018).

The presence of several water points in the fields or nearby and their use for the preparation of dilutions during treatment, might became an important health issue for human and animal those who consumed water of these water points. Some time, waters points are exposed to a potential contamination from the drift of treatment, runoff or infiltration. Further, different sources of pesticide might become potential sources of pollution of the water table through the water flows (Soleri, 2013).

From the recommendations and suggestions made, the producers showed that they are probably aware of the risk associated with pesticides and the means for a secure management. Indeed, the reduction in the number of pesticide treatments, the accessibility of medical visits after treatment, the availability and accessibility of PPE indicated the level of awareness of the danger posed by pesticides and the need to preserve them. Thus, the use of pesticides under the conditions described for the producers appears as a necessary evil which they now seem unable to cope with.

4.2 Characteristics of pesticides and risks to health

Apart from the glyphosate product KALACH, all the pesticides (herbicides, insecticides and fungicides) used by the producers have been identified at the level of the retailers. This suggests the global consideration of producers' needs by retailers. Thus, from a pesticide risk management perspective, there is a need to rigorously regulate the distribution of pesticides to avoid the use of unauthorized pesticides. For example, Beta-Cyfluthrin, class Ib, which is reported only from retailers and provided to producers by SOFITEX the previous campaign, is a prohibited pesticide (UTZ, 2015) that should be subject to a restriction of use in the context of agricultural practices in Burkina Faso.

Insecticides PYRINEX QUICK 424EC (deltamethrin and chlorpyrifos-ethyl), TIHAN 175 O-TEQ (spirotetramate and

flubendiamide), ACERO 84EC (isoclast, lambda-cyhalothrin), EMAPYR (emamectin benzoate, pyriproxyfen), and two glyphosate herbicides (LADABA, GLYPHADER) have been related to acute intoxication. The insecticides are quantitatively the most used, in three periods of treatment and repeated twice each by campaign (Traoré, 2008). These are more toxic to humans in terms of targets and mechanisms of action. These pesticides are composed of spirotetramate (Footprint PPDB, 2018), deltamethrin, emamectin benzoate, lambda-cyhalothrin, and isoclast, which are likely to be carcinogens or reprotoxic (Footprint PPDB, 2018), which may lead to chronic poisoning risks in case of repeated use. Glyphosate remains a highly controversial herbicide molecule classified as a possible carcinogen (Footprint PPDB, 2018) and is the most widely used herbicide molecule encountered. In addition, the pesticides used are mainly Class III (slightly dangerous) but contain CMR active substances or endocrine disruptors are available in these (Footprint PPDB, 2018). Also, paraquat based formulations are banned in Burkina Faso (FAO, 2018). Results of current study are in agreement with the findings of previous researchers (Toé et al., 2013; Convention de Rotterdam, 2016).

Conclusion

The study of pesticide characterization and analysis of the practices of pesticide stakeholders in rural areas made possible to understand the types of used herbicides or pesticides and risk associated with the use of these two. The harmful agricultural practices and dangerousness / toxicity of the used molecules lead to the exposure of intoxication in producers. Poor conditions involved the distribution of toxic and unapproved pesticides (CMR, endocrine disruptors, ecotoxicants, etc.), use of inappropriate PPE, short re-entry time, mixing of products, etc. Also, the non-formal marketing of pesticides and the illiteracy of the producers constitute important risk factors. Further, studies evaluating human exposure and environmental pollution are expected to better characterize the risk associated with pesticides in and around the Bala RBMH.

Conflict of Interest

The authors declare that there is no conflict of interest.

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