Original Research Article

Use of fertilizers and pesticides in vegetable growing and their impact on the ecosystem in the Comoé river watershed, Burkina Faso

ABSTRACT

Aims: This study was initiated to assess the impact of these practices on the CRW ecosystem. The aim of this study is to characterize pesticide and fertilizer use practices in vegetable growing in the Comoé river watershed (CRW).

Study design: This study was carried out on a sample of market gardeners chosen randomly. Data collection was done transversally.

Place and Duration of Study: This study was conducted in Western Burkina Faso during the dry period of 2020. It concerned market gardeners who carry out their activity in the ComoéBasin.

Methodology: To this end, a survey was carried out among a representative sample of 204 vegetable growers. The survey sheet was used to collect information on the level of education, speculations, origins of fertilizers and pesticides, and the management of fertilizers and pesticides in the CRW.

Results: The survey revealed that 92% of growers do not read labels on packages before using products, due to their low level of education (82%). The study also showed that 97% of respondents apply pesticides without any protection, and that only 16% of growers wash their bodies thoroughly after applying pesticides. Also, 82% of growers do not master fertilizer application dosage. Most growers do not consider the use of fertilizers and pesticides to be dangerous.

Keywords: Fertilizers, Pesticides, Vegetable growing, Pollution, Comoé river watershed

1. INTRODUCTION

The agricultural sector holds a prominent place in Burkina Faso's economy, as it employs 71% of the working population and contributes around 28.6% to good agricultural practices [1]. The area under cultivation is estimated at 3.6 million hectares. Vegetable crops account for less than 1% of cultivated area [2]. Despite this, they play an important role in improving the livelihoods and food security of small-scale farmers in developing countries [3,4]. According to [2], vegetable production generates more than 10 billion CFA francs a year for the national economy and directly employs more than 600,000 people, 35% of whom are women. The desire to increase agricultural productivity and incomes is leading farmers to make more frequent use of synthetic chemical products. However, mismanagement of these products can entail health and environmental risks [5]. Excessive use of compound or nitrogen fertilizers is a source of nitrates that contaminate surface and underground water [6]. In addition, the pressure of pests (parasites and harmful insects) is a major constraint on the vegetable-growing sector, and contributes to the decline in production and producers' incomes. Thus, to improve yields and meet ever-increasing market demand, the use of synthetic pesticides by producers is almost systematic [7,8]. Vegetable growing in sub-Saharan Africa often relies on the intensive, even abusive, use of inputs (mineral fertilizers, organic waste, phytosanitary products, wastewater), with consequences that are often harmful to human health and the environment [9,8,10,5]. On the one hand, it is observed that vegetable producers use inappropriate insecticides, and on the other, the methods of use, the lack of suitable protective equipment for users and storage conditions constitute aggravating risk factors for farmers and consumers [11]. Pesticides, which protect vegetable crops, help reduce agricultural production losses, but their use presents serious risks for both humans and the environment [12]. The Comoé River Watershed (CRW) is an agrosystem in which vegetable crops, sugarcane, cereals and cotton are expanding rapidly, given the intensification of activities in the area. The work of Coulibaly [13]. identified over 22 active molecules and 144 tons of pesticides used in the area. It is therefore legitimate to raise the concern about the possible risks of pollution of water resources by agricultural pesticides and mineral fertilizers. This raises the question of how to manage fertilizers and pesticides so as to promote the sustainable use of natural resources along the basin and enable it to fulfil all its ecosystem functions. Hence the interest in carrying out such an investigation in order to provide decision-support tools to actors involved in local development in the study area.

2. MATERIAL AND METHODS

2.1. Study area

The Comoé River Watershed is located in the western part of Africa between longitudes 2°45 and 5°58 West and latitudes 5°10 and 10°29 North. It is drained by a river 1160 km long that has its source in the Banfora region 420 m above sea level in Burkina Faso. It covers an area of around 78,000 km^2, and extends over the south-western region of Burkina Faso, the south-eastern parts of Mali and eastern Ghana, and the northern, central and southern regions of Côte d'Ivoire.
The Comoé Basin in Burkina Faso covers an area of 17,590 km^2, encompassing all or part of the provinces of Comoé, Léraba, Kénédougou, Houet and Poni. It is framed by latitudes 9°35' North and 11°05' North and longitudes 3°30' West and 5°30' West. It consists of five (05) main sub-basins: Comoé, Léraba, Kodoun, Baoué and Iroungou.
2.2. Sampling
Respondents were categorized by age and gender, based on the classification proposed by [14]. According to this structure, young people are those aged under 30, adults are those aged between 30 and 60, and old people are those aged over 60.
In the absence of a sampling frame of vegetable growers working in the Comoé basin, an empirical sampling method was used, namely that of quotas. Nevertheless, random sampling techniques were combined with the quota method. Sample size was determined using the proportion of growers who use chemical inputs in vegetable production in the study area. This information was obtained from agents in the Banfora technical support zone. According to them, nearly 85% of vegetable growers in the zone use chemical inputs. Therefore, the sample size was determined using Dagnelie's formula [15], which is also used by a number of authors such as[16].

$$n = \frac{z^2 p(1-p)}{e^2}.$$

Where n = sample size ; Z = margin rate deduced from desired confidence level rate z = 1.96 ; P (1-P) variance of the variable ; e = margin of error (e = 5% = 0,05).

This formula determines the number of people "n" to be interviewed according to the margin of error "e" that can be tolerated on a proportion of responses "p".
This gives a sample size of 196 vegetable growers. Assuming that the response rate for this type of survey is 95% in the locality, the size was adjusted to 206 vegetable growers. In all, 204 vegetable growers were surveyed, giving a response rate of 99%.

2.2. Survey procedure and data collection

Data collection was based on the following tools:
Individual interviews using a questionnaire with a sample of informal farmers. The questionnaire was integrated into an application (mWater) that not only made it possible to dispense with paper for survey purposes, but also to geolocate respondents (https://www.mwater.co).
The survey form was designed to provide information on the identity of the respondent, the origins of fertilizers and pesticides, and the impacts of fertilizers and pesticides on the natural environment. It also provides information on agricultural production, on the health of the population and on the attitude of vegetable growers towards water resources, as well as on pesticides and fertilizers.

2.3. Statistical analysis of data

The data collected in the field was processed automatically. The first step was to check that the questionnaires had been filled in correctly, and that the answers given by the respondents corresponded. This allowed the results sheets to be carefully examined so that they could provide the information.
The mWater application was chosen for its flexible operation and also because of its availability. It made it easier to digitally process data from our surveys on the socio-demographic characteristics of vegetable growers, the type and location of fertilizer supplies, the type of pesticides used, the validity period and source of supply, the management of leftover pesticides, the estimated quantities of fertilizer and the frequency of phytosanitary treatments, the period and safety measures during phytosanitary treatment, the participation of women and the safety measures used before, during and after phytosanitary treatment.

3. RESULTS

3.1. Socio-demographic characteristics of vegetable growers

The distribution of surveyed vegetable growers by gender and level of education is shown in table 1. It emerges that the majority are male (88). Most of the respondents are illiterate (168 out of 204). Only 9.80% of respondents claimed to have primary education.
Vegetable growing in the locality is done by young people and adults, with an average age of 37.

Table 1.Distribution of vegetable growers by gender, age and level of education

Variable	Gender of respondents		Ages of respondents			Level of education			
	Male	Female	Young	Adults	Old	Primary	Secondary	Literate	Illiterate
Frequency	167	37	56	145	3	20	8	8	168
%	82	12	27.45	71.08	1.47	9.80	3.92	3.92	82.36

The main activities practiced by vegetable growers are presented in table 2.
The results show that the main activity is rain-fed agriculture (90% of cases), followed by vegetable growing and trade.

Table 2. Importance of activities practiced by respondents

Activity	Importance of the activity	
	Main (%)	Secondary (%)
Rain-fed agriculture	90	7
Vegetablegrowing	7	91
Trade	1	1
Independante	1	0

3.2. Type of pesticides, fertilizers and place of supply

Local vegetable growers use both organic and chemical fertilizers. As a matter of fact, 91% of vegetable growers interviewed use both types of fertilizer. Only 9% use chemical fertilizers alone. Most of them (93%) look to the local market for their fertilizer supplies, as shown in picture 1.

Picture 1. Chemical inputs store at Banfora market

On the whole, vegetable growers in the Comoé River Watershed use pesticides that are sometimes unauthorized, and which they buy from the local market traders (Table 3).

Growers are unaware of the expiry date of the products they use. In fact, 48% of them say they do not know or do not pay attention to the validity period of the products.

Table 3. Pesticides and their toxicity classes in the study area

Order N°	Specialties	Classe OMS	Active ingredients	Approval
01	Lambda super 2.5 EC		Lambdacyalothrin	No
02	Nicoplus		Nicosulfuron 400D	No
03	Adwunawura		Glyphosate 480g/l	No
04	Kalach 360 SL	III	Glyphosate	Yes
05	Digafagalan	III	Glyphosate 360g/l	Yes
06	Herbextra	II	2.4-D amine salt 720g/l	Yes
07	Butaplus		Butachlor 50% EC	Yes
08	Atrazap 500 SC		Atrazine 500g/l	Yes
09	Success Appât	III	0.24 CB	Yes
10	Acarius 018 EC	II	Abamectin 18g/l	Yes
11	Indoxan	III	Indoxancarb 50g/l	Yes
12	Rangro 480 SL		Isopropylaminesalt Glyphosate	No
13	Connet super		Promethyne	No
14	Gramopat super		Paraquat chloride	No
15	Alligator	III	Pendimethalin	Yes
16	Emir fort	II	Acetamiprid 32g/l Cypermethrin 72g/l	Yes
17	Bifagana		Glyphosate 480g/l	Yes
18	Bomec	II	Abamectin 18g/l	Yes
19	K-optimal	II	Lambda cyalothrin Acetamiprid	Yes
20	Glyphader 360 SL	U	Glyphosate 360g/l	Yes
21	Glyphonet 360 SL	III	Glyphosate 360g/l	Yes
22	Ikokadigne	II	Halocyfop R methyl	Yes
23	Pacha	III	Acetamiprid 10g/l Lambda-cyalothrin 15g/l	Yes
24	Topstoxil			No
25	Forotigui 480 SL			No
26	Tihan		Spirotetramat	No
27	Ripro 720 SL			No
28	Pyriforce 480	II	Chlorpyrifosethyl 480g	Yes
29	Lambda power			No
30	Movento total		Spirotetramat	Yes

			Fulbendamide	
31	Round up 360	III	Glyphosate	Yes
32	Butaforce		Butachlor 50% EC	No
33	Activus	III	Pendimethalin	Yes
34	Binfaga Massa	III	Isopropylaminesalt	Yes
35	Primagold		5-metolachlor 35g/l Mesotrione Terbuthylasine	Yes
36	Calliherbe	II	2.4-D amine salt 720 SL	Yes
37	Herbimaïs		Atrazine 750g/kg Nicosulfuron	No
38	Akizon	III	Nicosulfuron	Yes
39	Bibana		Glyphosate 360g/l	Yes
40	Ladaba		Glyphosate 360g/l	No
41	Savahaler	II	Methonyl 250g/kg	Yes
42	Samory	III	Bensulfuron méthyl 100g/kg	Yes
43	Caïman rouge	II	Permethrin Thiram	Yes
44	Emacot	II	Emamectin benzoate	Yes
45	Stomp CS	III	Pendimethalin 455g/l	Yes
46	Benji		Acetamiprid 250g/kg	Yes
47	Bio k 16	U	Bacillus thuringiensis 16000ul/mg	Yes
48	Jumper 75 WC	U	Chlorothalonil 750g/kg	Yes
49	Almectine 20 EC	II	Emamectin benzoate	Yes
50	Delta Top 56 EC	U	Deltamethrin Acetamiprid	Yes
51	Tamega	II	Deltamethrin	Yes
52	Adwumayè		Glyphosate 480g/l	No
53	Gramoquest super		Paraquat chloride	No
54	Polytrine		Cypermethrin Profenofos	Yes
55	Benco		Mancozeb 80%	No
56	Bin'fla 720 WG		Glyphosate 360g/l	No
57	Coga	III	Mancozeb 800g/kg	Yes
58	Attakan C	II	Imidachloprid Cypermethrin	Yes
59	Montaz 45 WS	III	Imidacloprid 250g/kg Thiram 200g/kg	Yes
60	Heros		Glyphosate	Yes
61	Finish		Glyphosate 680g/kg	No
62	Thunder	II	Imidacloprid Betacyflutrin	Yes
63	Nomolt	III	Téflubenzuron 150g/l	Yes
64	Atia		Cypermethrin	No
65	B N°.01			No
66	Somon 40 EC		Acetamiprid Cypermethrin	No
67	Idefix	II	Copper hydroxyde	Yes
68	Malik 108 EC	III	Halocyfop-Rmethyl	Yes
69	Bibana 480 SL		Glyphosate 360g/l)	No

3.4. Managingleftover pesticides

Once the products have been acquired by the growers, they are stored at the vegetable-growing sites, in warehouses or at home. For most growers, the production site is the preferred place to store their produce.

Of all the growers surveyed, 90% store their products at their vegetable production sites, while 9% use warehouses for storage. Less than 1% of growers take the risk of storing products at home. What's more, almost all respondents claim to keep leftover products in their packaging for future use.

3.5. Estimating fertilizer quantities and treatment frequency

The survey revealed that 82% of vegetable growers have no method to estimate the quantity of fertilizer needed. It is therefore easy to understand why they use random dosages, without taking into account recommended dosage standards or the specificity of each crop. This can lead to overdosing, with economic, health and environmental consequences.

As for the type of treatment applied, 54% of growers use a calendar-based application and 40% a threshold application. The calendar application is initiated at each treatment date according to a calendar, whereas the threshold application is initiated following a prospection that determines the necessity of a treatment because an economic nuisance threshold has been reached.

3.6. Phytosanitary treatment period and safety measures

For many vegetable growers, there is no treatment period. 78% of the growers interviewed do it at any time. When treating vegetable crops, growers take wind direction into account to avoid inhaling as much of the product as possible, which will undoubtedly have consequences for their health. These basic precautions are known to almost all vegetable growers, but they do not use protective equipment.

3.7. Women's participation

The survey revealed that 13% of growers are women, who also take part in phytosanitary treatment, generally for their small farms. The treatment activity is therefore not restricted to men in this locality.

3.8. Precautions before, during and after phytosanitary treatment

Before treatment, only 8% of them read the labels on the packages. This may be linked to their level of education, with 82% of vegetable growers unable to read or write.

None of the growers smokes during treatment, according to the survey results. However, nearly 26% communicate by telephone during treatment.

After treatment, as shown in the graph (Table 4), 81.37% washed only their hands, while 16% washed their whole body.

Table 4. Distribution of vegetable growers according to post-treatment hygiene measures

	Wash the body	Wash hands only	Drink milk	Do nothing
Frequency	32	166	2	4
%	15.69	81.37	0.98	1.96

After pesticide application, 69% of respondents burn the empty containers. Others bury them (10%) or use them for other purposes, when they are not abandoned in the open (21%), as shown in picture 2.

Picture 2. Pesticide packaging abandoned in the open

4. DISCUSSION

In Burkina Faso, the main activity of most rural populations is rain-fed agriculture. In the Comoé river watershed, vegetable growing is a secondary occupation that plays an important role in producers' financial and food security. The analysis of the results shows that the vegetable sector is dominated by men (88%). This observed tendency is in line with statistics obtained nationwide [2,17]. The reason for this is that vegetable growing is a tedious activity and requires financial resources that women often do not have. Also, men generally have more access to land than women, and vegetable-growing activity in the area is supervised by the heads of households, who are generally men, hence this distribution of the sample. According to the [18], gender inequalities in land rights are widespread. Women's access to land is limited (less than 10% in West Africa) and is often restricted to secondary land rights, meaning that they hold such rights through male family members.

The study revealed that most vegetable growers (around 82%) are neither educated nor literate; this could be a major obstacle to exploiting the information on the label, which provides information on the safe use of the product. Only 8% of respondents read the labels on the packages, and it also emerged that almost 26% communicate by telephone during treatment. This situation could be linked to their level of education. Indeed, a grower's level of education influences his mastery of modern production techniques. Moreover, vegetable growers with an advanced level of education have more opportunity to obtain the necessary information on the products they use on their farms, and are more receptive to the dangers posed by uncontrolled use of certain products. This result corroborates the work of [19], who showed that illiteracy is one of the toxicological risk factors among pesticide users. Other studies, such as those by [20]in Benin, have also stated that 7 out of 10 farmers have never been to school, and that of those who have, only 1 in 3 has completed primary school. According to [21], the development of agricultural strategies should pay special attention to education and information dissemination for producers. These factors have a major influence on pesticide use and pesticide waste management. In the CRW, almost all respondents say that they keep the pesticide remaining in its container after phytosanitary treatments for future use; however, the remaining mixture is systematically poured off. This raises the question of how surplus mixture is managed, as it constitutes an environmental risk factor. Dumping or burying the remaining mixture can contaminate water through runoff or infiltration. According to [22], water pollution could cause a public health problem, as surface or well water is used daily for food. This situation permanently exposes aquatic organisms to pesticide residues, some of which can persist for several years in the environment [23]. Also, the existence of surplus mixture is proof that growers are unable to determine the quantity of mixture required for the area to be treated. This confirms the findings of [24], on risk diagnosis (risk and exposure factors, frequency of environmental pollution) in the eastern cotton-growing region of Burkina Faso, who

concluded that in matters of mixture preparation, growers were unable to determine the quantity of mixture according to the area to be treated. In fact, work by [25] in the Benin cotton basin showed that growers are still very unaware of the rational use of phytosanitary products. After pesticide application, empty packages are for the most part destroyed that is to say burnt (69%). Similar results were obtained by [19], who also found that empty packages were abandoned in the open, burnt, buried or reused. Indeed, some people bury them (10%) or use them for other purposes, when they are not abandoned in the open (21%). Abandoning empty packages and burying them in the ground is a factor of environmental pollution, since all packages are made of non-biodegradable materials and will therefore remain in the ground for years.
Concerning precautions taken by growers when using pesticides, our interviews with them revealed that 97% do not use any protective equipment when applying pesticides.
Of all the growers interviewed, almost 58% wash in water points, while 41% do so in the field. On the other hand, 88% wash their equipment in the field after pesticide application [24]. found similar results in the eastern cotton-growing zone of Burkina Faso. The survey also revealed that the majority of growers use chemical fertilizers, but only 12% of them know how to apply and use them. This lack of knowledge of fertilizer dosages could affect the sustainability of vegetable-growing systems and pose a risk to the environment [6]. In fact, the work of [17]. in the western region of Burkina Faso has shown that most vegetable growers use mineral fertilizers and are aware of the dangers associated with their use on water and soil fertility in the long term.

CONCLUSION

Vegetable-growing in the Comoé river watershed remains the main activity for farmers in the dry season, but it encounters a number of difficulties. Beyond the economic profitability of this activity, it should be recognized that there is a major issue relating to the ecosystem risks inherent in fertilization and plant protection practices that do not respect the rules for the safe management of chemical inputs.
In order to protect farmers' health, and consequently public health and the environment, measures and actions need to be taken. Proposals to achieve this include strict control of the quality of fertilizers and pesticides used on the different vegetable-growing areas and, more generally, the safe management of chemical inputs in agriculture; sensitization on the dangers of phytosanitary products, which should focus on pollution problems, particularly water pollution and its consequences on human and environmental health.
It would therefore be wise to encourage and promote biological pest control in order to protect human and animal health, as well as the environment.

REFERENCES

1. World Bank (2019): https://donnees.banquemondiale.org/politique/NV.AGR.TOTL.ZS

2. MAH. Phase 2 RGA 2006-2010 - General report of the Market gardening module, 2011; P31.

3. Schreinemachers P., Simmons E.B., Wopereis M.C. Tapping the economic and nutritional power of vegetables. Global. Food Security., 2018; 16, 36–45.

4. Sedani SR, Pardeshi IL, Bhad RG, Nimkarde PG. Vegetables: A boon to human healthy life. J. Ready Eat Food, 2018; 5, 22–30.

5. Hadjer R, Fateh M, Kamel G, Kamel C. Use of pesticides and risk perception among farmers in the Biskra region (South East of Algeria), International Journal of Environmental Studies, 2020; 77 (1): 82-93, DOI: 10.1080/00207233.2018.1534400

6. Bafai DD, Tchegueni S, Bodjon MB, Koriko M, Tchangbedji G, Merlina G. Determination of Pesticide Residues in Soils of Cotton Farming Areas in Togo. Journal of Agricultural chemistry and environment, 2022; 11:285-295

7. Kanda M, Akpavi S, Wala K, Djaneye-Boundjou G, Akpagana K. Diversity of cultivated species and constraints on production in market gardening in Togo. International Journal of Biological and Chemical Sciences, 2014; 8(1): 115-127.

8. Mondéedji AD, Amevoin K, Nyamador SW, Adeoti R. Analysis of some aspects of the vegetable production system and producers' perception of the use of botanical extracts in the management of insect pests of market garden crops in southern Togo. International Journal of Biological and Chemical Sciences, 2015; 9 (1):98-107.

9. Houndéetée TA, Hougni A, Aladji S, Dagoudo A, Zoumarou-Wallis N, Thomas-Odjo AA. Behavior of the main pests and cotton diseases on proven varieties of cotton (Gossypium hirsutum) under different doses of fertilizer in Angaradébou in Benin. International Journal of Biological and Chemical Sciences, 2015; 9(1): 217-224 DOI: 10.4314/ijbcs.v9i1.19

10. Agboyi LK, Ketoh GK, Martin T, Glitho IA, Tamò M. Pesticide resistance in Plutellaxylostella (Lepidoptera: Plutellidae) populations from Togo and Benin. International Journal of Tropical Insect Science, 2016; 36 (4): 204-210.

11. Ahouangninou C, Martin T, Assogba-Komlan F, Cledjo P, Kpenavoun CS, Nouatin G, Boko W, Soumanou MM, Houssou C, Biaou G, Ahanchede A, Boko M, Fayomi B. Assessment of production sustainability market gardener in the south of Benin. Cahiers du CBRST, 2015; 2 (7): 98-126.

12. Toé AM and Coulibaly M. Evaluation of the effects of the 2004 locust control on the health of populations and the environment in Burkina Faso. Sahelian studies and research, 2016; 13:7-9.

13. Coulibaly L, Coulibaly S, Kamagate B, Sekongo N, Savane I, Gourene G. Distribution of Pesticides of Agricultural Origin and Assessment of the Vulnerability of Water Resources in a Transboundary Watershed: Case of Comoé, Ivory Coast European Journal of Scientific Research, 2012; 76 (4): 601-613.

14. Assogba-Komlan F, Anihouvi P, Achigan E, Sikirou R, Boko A, Adje C, Ahle V, Vodouhe R, Assa A. Cultivation practices and content of anti-nutritional elements (nitrates and pesticides) of Solanum macrocarpum in the south of Benign. African Journal of Food, Agriculture, Nutrition and Development, 2007; 7:1-21.

15. Dagnelie P. Theoretical and applied statistics. Brussels: De Boeck, 1998; 517 pp.

16. Gbemavo CJSD, Gnangle CP, Assogbadjo EA, Glele Kaka LR. Analysis of local perceptions and factors determining the use of organs and products of Jatropha curcas Linn. (Euphorbiaceae) in Benin. African Agronomy, 2014; 26 (1): 69 - 79

17. Ouédraogo RA, Kambiré FC, Kestemont MP, Bielders CL. Characterize the diversity of market gardening farms in the Bobo-Dioulasso region in Burkina Faso to facilitate their agroecological transition. Cah. Agric., 2019; 28, 20. https://doi.org/10.1051/cagri/2019021

18. FAO. Economic and social perspectives. Summary 8, 2010; 2p.

19. Ouédraogo M, Tankoano A, Ouedraogo TZ, Guissou IP. Study of risk factors for poisoning among pesticide users in the cotton-growing region of Fada N'Gourma in Burkina Faso. Environment, Risks & Health, 2009; 8 (4): 343-347.

20. Fayomi B, Lafia E, Fourn L, Akpona S, Zohoun T. Knowledge and behavior of pesticide users in Benin. African Newsletter, 1998; 2:40-3.

21. Archer A. The education of farmers, their age and the productivity of agricultural inputs according to the size of dairy farms: the case of region “04”, Quebec / Farmer's education, their age and the productivity of agricultural inputs according to milk farm sizes: the case of region "04", Quebec. Economic News, 1981; 57 (1): 113-127.

22. Le Bars M, Sidibe F, Mandart E, Fabre J, Le Grusse P, Diakite CH. Assessment of risks linked to the use of pesticides in cotton cultivation in Mali. Cah. Agric., 2020; 29:4.

23. Barrault J. Responsibility and environment: questioning the amateur use of pesticides. VertigO - the electronic magazineeu in environmental sciences, 2009; Special issue 6. DOI: https://doi.org/10.4000/vertigo.8937

24. Gomgnimbou APK, Savadogo PW, Nianogo AJ, Millogo/Rasolodimby J. Use of chemical inputs in a tropical agro system: diagnosis of the risk of environmental pollution in the cotton-growing region of eastern Burkina Faso. Biotechnology. Agron. Soc. Approx., 2009; 13(4):499-507.

25. Adechian SA, Baco MN, Akponikpe I, Toko II, Egah J, Affoukou K. “Farmer practices for pesticide management on corn and cotton in the cotton basin of Benin”, VertigO - the electronic journal in science of the environment, 2015; 15 (2), http://journals.openedition.org/vertigo/16534; DOI: https://doi.org/10.4000/vertigo.16534