INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 25, No. 2, p. 98-110, 2024
http://www.innspub.net

RESEARCH PAPER | OPEN ACCESS

Health and environmental associated risks with the use of agricultural chemical inputs in Tchaourou, Benin

Hervé Hotèkpo Akodogbo*[1,2], Abdoulaye El-hadj Boni Soumanou[3], David Darius Adje[4], Ibouraïma Yabi[3]

[1]*Polytechnic School of Abomey-Calavi (EPAC), University of Abomey-Calavi, Cotonou, Benin*

[2]*Faculty of Science and Technology, University of Abomey-Calavi, Cotonou, Benin*

[3]*Department of Geography and Regional Planning (DGAT), University of Abomey-Calavi, Cotonou, Benin*

[4]*Faculty of Agronomy (FA), University of Parakou (UP), Parakou, Benin*

Article published on August 06, 2024

Key words: Agricultural chemical inputs, Environment, Human health, Misuse, Risks

Abstract

The aim of this study was to analyze the risks associated with the use of agricultural phytosanitary products on environment and human health in Tchaourou, Benin. To do so, 250 producers using chemical agricultural inputs in the environment were randomly selected and distributed among the 16 villages. The results from field surveys revealed that 80% of producers in the Municipality of Tchaourou use chemical agricultural inputs, including 52% who obtain them informally. Likewise, illiteracy (61.6% of farmers) and the lack of training in the use of pesticides do not promote good phytosanitary practices. In addition, failure to wear protective equipment (96.5% of cases) and failure to comply with the dosage recommended by the agricultural council (76%), as well as poor management of pesticide waste abandoned on farms exposes populations at risk with a potential direct impact on human health and environmental components (soil, water, etc.). Thus, suggestions were proposed to promote rational management of pesticides and improvement of phytosanitary practices of farmers in this environment. This study therefore constitutes a call to individual and collective conscience for the safeguarding of biodiversity and human health in Tchaourou.

***Corresponding Author:** Hervé Hotèkpo Akodogbo ✉ hakodogbo1@gmail.com

Introduction

Agriculture is an essential component of the Beninese economy (MAEP, 2020). This importance is measured on three dimensions: (i) the contribution of the sector to the national economy, (ii) the proportion of the working population employed in the agricultural sector and (iii) the decisive role played by local production in food security in Benin (Soulé, 2024).

However, global demographic growth models predict that by 2050, about 9.7 billion people will need to be fed on Earth (Dutoit, 2023). This situation, which requires an increase in agricultural production, has led farmers to use pesticides and chemical fertilizers. Offered in solid or liquid form, these synthetic products have a rapid action, as they do not need to decompose in the soil for the nutrients they contain to be absorbed by plants. This promotes good soil fertility and better yields (Dutoit, 2023).

However, the use of these plant protection products represents a growing threat to humans, animals and environment (Ake *et al.*, 2023). Despite the effectiveness of pesticides on pests and their positive effect on increasing yields, several studies in Benin (Ahouangninou *et al.*, 2011; Agbohessi *et al.*, 2011), Togo (Kanda, 2011), and Burkina Faso (Lehmann *et al.*, 2016) have shown that the repeated and uncontrolled use of chemicals for plant protection is not without consequences for the health of farmers, consumers or environment. They can not only pollute the air, soils to the point of making them sterile, poison water and contaminate drinking water sources, but also dangerously impact human health. The use of pesticides can have serious repercussions (teratogenicity, neurotoxicity, reproductive toxicity, and carcinogenicity) on the health of farmers, consumers, and the quality of the environment, as the toxicity of these agricultural inputs has been demonstrated by several toxicological and ecotoxicological studies (Wolf *et al.*, 2023; Coulibaly, 2022; Soumaré *et al.*, 2020; KpanKpan *et al.*, 2019; Kanda, 2011; Gomgnimbou *et al.*, 2009). In addition to their environmental toxicity, some fertilizers are explosive and likely to release toxic gases (Le monde, 2021). The use of chemical inputs is therefore frequent and prolonged, most often in total ignorance of the application rules and non-compliance with recommended dose (Gouda *et al.*, 2018).

Thus, the aim of this study was to analyze risks associated with the use of chemical plant protection products on environment and human health in Tchaourou, Benin since agriculture in this locality plays a crucial role in the local economy. Moreover, its regional representativeness, and the need to improve understanding of the challenges facing farming communities have guided the choice of this specific region. It is in the light of all this we have initiated this study with the challenge of advocating an increase in agricultural production while preserving the environment and human health.

Materials and methods

Study environment

Located in the Borgou department between 2°31'28" and 2°46'43" East longitude and between 8°46'04" and 8°59'25" North latitude (IGN-Benin, 1992), Tchaourou is the gateway to Borgou department and covers an area of 7256 km², which represent 28% of the total area of this department and approximately 6.5% of the national territory. It is bordered to the north by the communes of Parakou, N'Dali, and Pèrèrè; to the south by the commune of Ouèssè. It is adjacent to the Federal Republic of Nigeria to the east and west, and is bordered by the communes of Bassila and Djougou. It is divided into seven (07) arrondissements (Tchaourou, Tchatchou, Sanson, Goro, Bétérou, Alafiarou, and Kika), with the arrondissement of Tchaourou as the commune's administrative center. The dominant linguistic groups are the Yoruba, Nago, and related groups, the Bariba, the Fon, the Mahi, and the Ottamari and related groups (Ousmane, 2006).

The vegetation encountered is savanna with some deciduous forests and forest galleries growing on a tropical ferruginous soil that is slightly concreted. The main watercourse in this essentially rural commune is the Okpara, with approximately 70% of the population engaged in agriculture. The traders account for about 15%, followed by artisans at 10%, and other sectors of activity at 5% (Amadou and Agbo, 2017). The Fig. 1 presents the geographical situation of the study area.

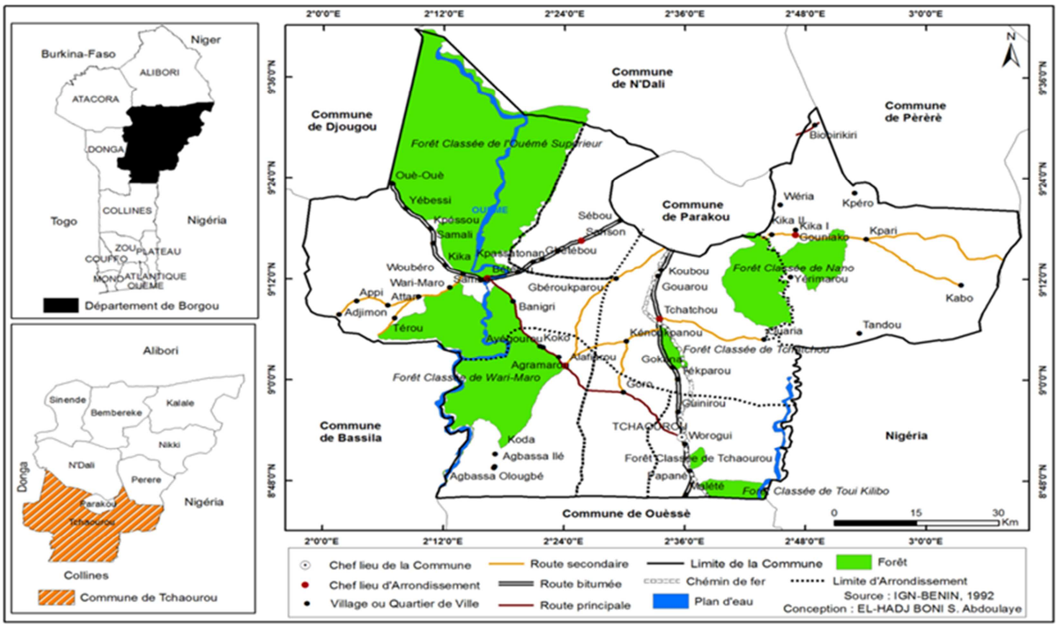


Fig. 1. Administrative map of Tchaourou

Source: (Ousmane, 2006) In Monograph by Tchaourou

Data collection and collection techniques

Data were collected using four techniques: (1) documentary research, (2) interviews, (3) questionnaires and (4) direct observation using an observation grid. Data analysis followed the creation of a database entered into Excel software. A descriptive analysis of the data was carried out in Excel in order to identify the major trends and compare the observations.

Sampling

Four districts were identified to conduct the survey based on the importance of agricultural production and the use of chemical agricultural inputs (fertilizers and pesticides) in Tchaourou (Goro, Kika, Tchatchou and Tchaourou). The same criteria were then used to select four villages in each of the selected districts. A total of sixteen villages were thus surveyed in the study area. To minimize the similarity of information, these 16 selected villages are at least five kilometers apart. Producers using chemical agricultural inputs are considered as research units. The sample size N was determined using the Dagnelie (1998) formula.

$$N = \frac{z^2 \times p\,(1-p)}{m^2}$$

With z = 1.96 representing the confidence level according to the standard normal distribution (95%). The sampling error margin m *set* for this research is 0.05 and p = 0.80 representing the proportion of producers using chemical agricultural inputs. This proportion is defined based on a preliminary survey conducted with fifty (50) randomly selected producers in the identified villages, to whom we asked whether they use chemical agricultural inputs in their production system. As a result of this investigation, it appears that 80% of the producers in Tchaourou use chemical agricultural inputs. The use of this proportion p in the Dagnelie formula revealed a value of N = 245.86 (≈ 246). As a result, 250 producers using chemical agricultural inputs in the area were randomly interviewed across the 16 villages (Table 1). Table 1 present the four districts of the commune of Tchaourou in which the research was carried out, the villages chosen in each of the districts to carry out the survey as well as the number of producers surveyed per village.

Table 1. Sampling summary

Districts	Villages	Producers surveyed	Proportion (%)
Goro	Gah-Gourou	15	6
	Gbéba	15	6
	Goro	15	6
	Nim Soambou	15	6
Kika	Bonwoubérou	15	6
	Kpassa	15	6
	Gouroubara	16	6.4
	Kpari	16	6.4
Tchatchou	Soumon-gah	16	6.4
	Kontoubarou	16	6.4
	Gararou	16	6.4
	Kinnou-Kparou	16	6.4
Tchaourou	Kassouala	16	6.4
	Yambouan	16	6.4
	Gango	16	6.4
	Borori	16	6.4
Total		250	100

Source: Field survey, July 2023

Assessment of the degree of toxicity of pesticides

There are different types of pesticides, such as insecticides, herbicides, fungicides, etc. Each class has different modes of action and can present different risks to human health and the environment. Information on the plant protection products used, the active substances they contain, the supply channels, the toxicity and other characteristics were available online www.agritox.anses.fr, www.echa.europa.eu/en/regulations/clp/classification (Classification, Labelling and Packaging of substances and mixtures) and www.sagepesticides.qc.ca.

Data processing and analysis

During this phase, the questionnaires addressed to the different actors were manually processed to determine the rate of the different response groups, particularly the positive and negative responses from various questions. The second phase was dedicated to the computer processing of the data (data entry, compilation, and grouping by area of interest). Word 2010 software was used for text processing and Excel for creating data entry templates, generating tables, and creating graphs. The analysis of the numerical information collected allowed the creation of figures and curves for certain variables and also generated the use of certain formulas, as the arithmetic mean, which led to the determination of the average area used by producers in Tchaourou. As for the frequency formula, it allowed determining the proportion of the different crops in the study area.

Results

Socio-demographic characteristics of the producers surveyed

Due to its geographical location, Tchaourou has an important sociocultural diversity that makes it heterogeneous in terms of population. Socio-demographic characteristics of producers in Tchaourou were summarizing in Table 2.

Table 2. Socio-demographic characteristics of producers in Tchaourou

Ages in years	No	Proportion (%)
[20-30]	55	22
[31-40]	110	44
[41-50]	80	32
[51-60]	4	1.6
[61-70]	01	0.4
Genders		
Male	195	78
Feminine	55	22
Education Levels		
None	154	61.6
Primary	65	26
Secondary	22	8.8
University	9	3.6
Linguistic affiliations		
Bariba	95	38
Nago	52	20.8
Peulh	44	17.6
Adja	12	4.8
Djerma	5	2
Ditamari	30	12
Lokpa	12	4.8
Household size		
[0-5]	76	30.4
[6-10]	109	43.6
[11-15]	59	23.6
[16-20]	6	2.4
Sown area		
[0-5 ha]	188	75.2
[6-10 ha]	36	14.4
11-15 ha]	12	4.8
[16-20 ha]	08	3.2
[21-25 ha]	05	2
[26-30 ha]	01	0.4

Source: Field survey, July 2023

The analysis of Table 2 shows that producers surveyed in Tchaourou were aged between 20 and 70. Thus, one hundred and ten (110) producers, or 44%, are between 30 and 40 years old, eighty-eight (80) of them, or 32%, are between 40 and 50 years old, while the age of fifty-five (55) of them, or 22%, is between 20 and 30 years. Four (4) producers, or 1.6%, are between 50 and 60 years old, and only one (1), or 0.4%, is between 60 and 70 years old. In this study, both men and women are engaged in agricultural activities. Thus, surveys show that 78% were male with and 22% were female. From analysis of producers' ages, 35 years is the average age of the surveyed producers, which attests to the youth of the producers in the study area. Considering ethnicity, Bariba are the most represented (38% of people surveyed), followed by Nago (20.08%) and Peulh (17.06%). The other four ethnic groups were less represented. Considering the education, it appears that they have various levels of education.

Thus, one hundred and fifty-four (154) of them, or 61.6%, are illiterate, sixty-five (65), or 26%, have a primary level, while twenty-two (22), or 8.8%, have a secondary level. Only nine (9), or 3.6%, have a university level. The large number of illiterates among the producers accentuates their ignorance of the health risks associated with the use of chemical agricultural inputs, as they cannot read the labels on which the precautions to be taken before handling these harmful products are prescribed. The survey results show that one hundred and sixty (160) of the producers surveyed are married, sixty-five (65) are single, twenty-two (22) are divorced, and three (3) are widowed. As for the cultivated area, one hundred and eighty-eight (188) producers, or 75.2%, have between 0 and 5 hectares, then thirty-six (36) producers, or 14.4%, have between 6 and 10 hectares, while twelve (12) producers, with a percentage of 4.8%, have between 11 and 15 hectares. Eight (8) of them, or 3.2%, have between 16 and 20 hectares, while five (5), or 2%, have between 21 and 25 hectares, and finally, only one (1) producer, or 0.4%, cultivates between 26 and 30 hectares. The survey results reveal that one hundred and nine (109) producers, or 43.6%, have a household size between 6 and 10 individuals, and seventy-six (76) of them, or 30.4%, have a household size between 0 and 5 individuals, while fifty-nine (59), or 23.6%, have a household size between 11 and 15 individuals, and finally, only six (6), or 2.4%, have a household size between 16 and 20 individuals. These results confirm the availability of a qualified workforce for agriculture.

Methods of supplying producers with chemical agricultural inputs

Based on the field surveys, it has been determined that the agricultural inputs utilized in Tchaourou originate from multiple sources. The Society for Cotton Development (SODECO) is the official body responsible for the sale and distribution of inputs to producers. However, given the geographical expanse between districts, GIE Sarl has been authorized to distribute approved products, supplying inputs to three traders in the Goro district, five in the Kika district, and four in the Tchatchou district. Additionally, there is a significant informal sector comprising local markets, producers themselves, street vendors, and external markets, notably from the Federal Republic of Nigeria. Survey data indicates that 52% of producers using chemical inputs find products from formal sources to be prohibitively expensive, opting instead for informal sources. Meanwhile, 18% procure inputs from both formal and informal sources, and 30% solely rely on formal sources. Fig. 2 depicts the various sources of agricultural inputs within the Commune of Tchaourou.

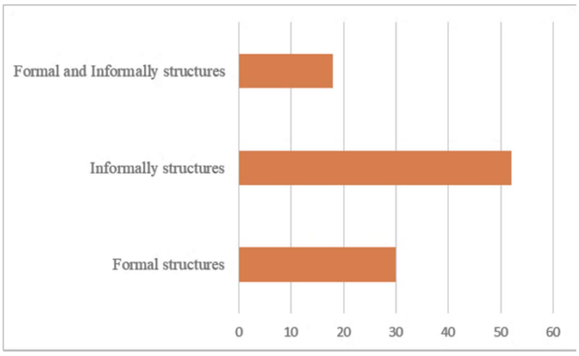


Fig. 2. Frequencies of producers' sources of supply of agricultural inputs

Source: Field survey, July 2023

Methods of storage of chemical agricultural inputs by producers before use

Chemical agricultural inputs are not stored under the same conditions by producers (Fig. 3). Inputs are stored either in cooperative stores, in homes, or in field stores. It is worth noting that some producers obtain them on the day of use.

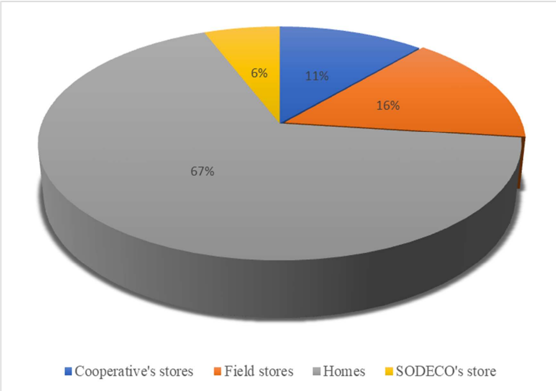


Fig. 3. Places for storing inputs before their use

Source: Field survey, July 2023

Observation of the Fig. 3 reveals that 67% of producers using chemical agricultural inputs store them before use in their homes, while those using field stores are only 15.5%. 11.5% store their inputs in cooperative stores, and 6% buy from SODECO's store on the day of use.

This prevalence of those using homes for storage increases the risks associated with the use of these phytosanitary products.

Dosage of chemical agricultural inputs by producers

The dosage of inputs varies from one producer to another. The large number of illiterates among them does not allow them to read and respect the dosage, which is inscribed on the containers of the inputs.

Dosage of pesticides by producers

The dosage of pesticides among the surveyed producers exhibits considerable variability. The preparation of pesticide mixtures differs significantly from one producer to another. Field surveys reveal that 76% of producers apply an excessive amount of pesticides, disregarding the recommended dosages provided by agricultural advisors. Specifically, 42% of producers use the caps of pesticide containers for measuring dosage, with the number of caps depending on both the size and nature of the weeds. For large weeds, they use five caps per hectare, four caps for medium-sized weeds, and three caps for small weeds. Additionally, 18% of producers use two caps per 16 liters of water, resulting in the application of four caps per hectare. When delayed in their application, they may increase this to three caps per 16 liters, using five caps per hectare. Furthermore, 16% use tomato boxes for measuring, applying four caps per hectare, contrary to the agricultural recommendations which advise against waiting for weeds to grow large and suggest a dosage of 2 to 3 caps per hectare. Only 24% of producers adhere to these guidelines. It is also noted that some producers use maize treatment products for soybean treatment and vice versa. Table 3 details the various insecticides and herbicides, along with the quantities necessary to combat pests such as the fall armyworm and various weeds.

Table 3. Classification of pesticides

Terms of use	Products	Quantity to use/Ha
Fight against armyworm	Emacot	500ml/0,5ha
	Lamdacyalothrine	2 vials/ha
	Pacha	2 vials/ha
	Malathion	2 vials/ha
	Radian120 SC	2 vials/ha
	Marel 30 EC	2 vials/ha
	Gbayedo56 EC	2 vials/ha
	Emace 40 EC	2 L/ha
Weed control	Nicosib 40 SC	2 to 3 vials/ha
	Faaba tiya 40 SC	2 to 3 vials/ha
	Nico gold 40 SC	2 to 3 vials/ha
	Pendi gold 400 SC	2 to 3 vials/ha
	Lagon 575 SC	2 vials/ha
	Sofa 40 SC	2 vials/ha
Crop growth and yield	NPK/ SSP	3 bags/ha
	UREE	1 bags/ha

Source: Documentary synthesis and field survey, July 2023

Analysis of Table 3 reveals that each agricultural input has a specific function, usage conditions, and recommended quantity per hectare. Insecticides are employed to control insect populations, herbicides to manage weed growth, and fertilizers to enhance plant growth and crop yields. Herbicides such as Nicosib 40 SC, Faaba tiya 40 SC, Nico gold 40 SC, and Sofa are classified as post-emergence herbicides, indicating their application occurs after the crops have emerged. Conversely, herbicides like

Pendi gold 400 SC and Lagon 575 SC are categorized as pre-emergence herbicides, used prior to crop emergence. Fig. 4 illustrates the distribution of producers based on their adherence to the recommended pesticide dosages.

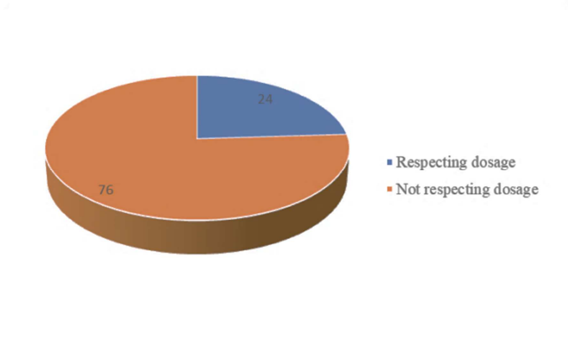


Fig. 4. Distribution of producers respecting the dosage of pesticides and those not respecting it
Source: Field survey, July 2023

Observation of the Fig. 4 reveals that 76% of surveyed producers do not respect the recommended dosage by encoders. These producers over-dose. Only 24% respect the encoders' recommendations.

Dosage of chemical fertilizers by producers

Chemical fertilizers used in the Commune of Tchaourou include UREA, NPK, and SSP. The SSP fertilizer is a newly developed product specifically designed for staple crops. Similar to pesticides, the application of chemical fertilizers varies among producers. Surveys indicate that 67% of producers use two bags of UREA (100 kg/ha), contrary to the recommended one bag (50 kg/ha), and four bags of NPK/SSP (400 kg/ha) instead of the suggested three bags (150 kg/ha). These recommended dosages are intended for all crop types. SSP fertilizer is applied post-weeding and pre-plowing, while NPK is applied after plowing and sowing. Producers justify this over-application by claiming it is necessary for achieving good yields. However, agricultural advisors warn that over-dosing accelerates soil depletion and increases the risk of intoxication. Fig. 5 depicts the distribution of producers who adhere to the recommended chemical fertilizer dosages versus those who do not.

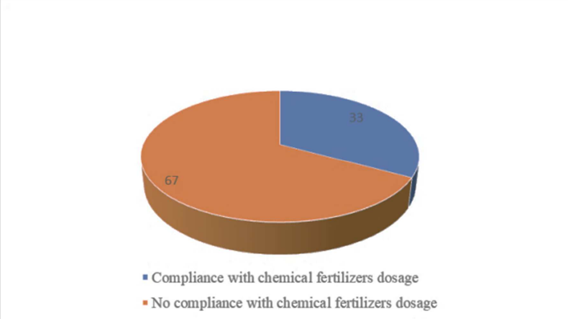


Fig. 5. Distribution of producers according to whether or not they respect the recommended dosage of chemical fertilizers
Source: Field survey, July 2023

Wearing of appropriate personal protective equipment by producers

Personal protective equipment (PPE), including a full-body suit, gloves, boots, face masks, and goggles, is recommended by agricultural advisors to protect producers from health risks associated with the use of chemical agricultural inputs. Paradoxically, despite these recommendations, producers often neglect these safety measures when handling hazardous phytosanitary products. In the study area, 77.2% of producers use protective measures, while 22.8% do not employ any protective measures before treating their fields. Table 4 details the proportions of PPE usage among producers.

Table 4. Proportions of use of PPE by producers

Use of protective equipment	User numbers	%
Lack of measurement	57	22.8
Nose cover	75	30
Boots	37	14.8
Gloves	14	5.6
Outfit	12	4.8
Glasses	9	3.6
Outfit and boots	6	2.4
Mask and glasses	10	4
Outfit and gloves	8	3.2
Outfit, boots and muffler	6	2.4
Outfits, mufflers and gloves	5	2
Gloves, boots, muffler, and glasses	4	1.6
Mask, boots, glasses and outfit	3	1.2
Mask, boots, glasses, outfit and gloves	4	1.6
Total	250	100

Source: Field survey, July 2023

Analysis of Table 4 reveals that not all surveyed producers use personal protective equipment (PPE).

Specifically, 22.8% do not use any protective equipment. Among the 77.2% who do protect themselves, 30% use face masks, believing that the nose and mouth are critical entry points for chemical inputs and therefore make an effort to protect these orifices. Additionally, 14.8% use boots only, 5.6% use gloves only, and 4.8% wear the suit alone. Goggles are employed by 3.6% of producers, while 2.4% use a suit-boots combination. Furthermore, face masks and goggles are used by 4%, the suit and gloves by 3.2%, and the suit-boots-face mask combination by 2.4%. Only 2% use a suit-face mask and gloves combination, 1.6% use gloves, boots, face mask, and goggles, and 1.2% use the face mask, boots, goggles, and suit combination. The combination of face mask, boots, goggles, and gloves is used by 1.6% of producers.

The reasons given for non-use of PPE are varied. A significant 38% of producers believe that the equipment is prohibitively expensive, while 26% cite a lack of financial means to purchase it. Another 18% hope for free distribution of PPE by the government, and 12% are unaware of the importance of protective equipment beyond face masks, as they believe only the mouth and nose need protection from chemical input exposure. Additionally, 6% of producers feel that wearing PPE adds an extra burden on top of carrying the sprayer, making them uncomfortable during field spraying. Fig. 6 illustrates an unprotected farmer spraying his maize field.

Fig. 6. An unprotected farmer treating his corn field

Source: Field survey, July 202

Management of input packaging by producers

The management of pesticide packages varies based on the population's awareness of the environmental and health risks posed by their contents. In the study area, three primary disposal methods have emerged. The first category involves packages being discarded into the environment or buried in the soil. The second category is incinerated, while the third category is repurposed for domestic uses such as storage or water containers. Despite the presence of several facilities in Benin dedicated to managing agricultural inputs, local populations are left to handle used pesticide packages independently, resulting in numerous social, economic, and environmental impacts. Fig. 7 illustrates the different methods employed by producers for managing pesticide packages post-use.

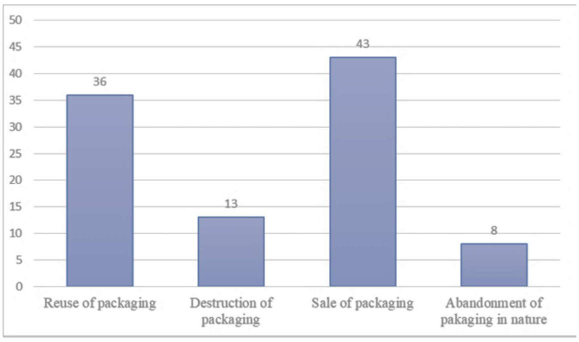


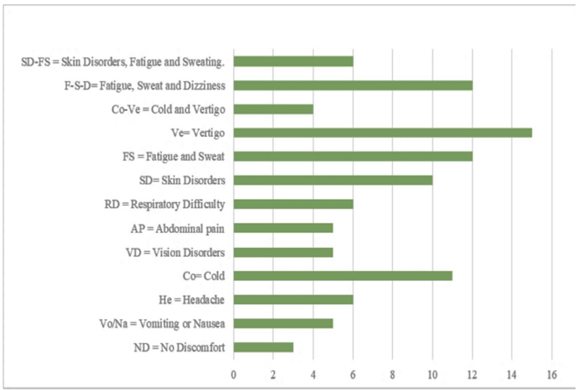
Fig. 7. Management of pesticide packaging after use

Source: Field survey, July 2023

Fig. 8. Use of pesticide packaging as a drinking water bottle by a child

Source: Field survey, July 2023

The analysis of the Fig. 7 shows that 43% of producers resell pesticide packages, which allows noting the exposure of packages in local markets. 36% reuse these packages for storing food and petroleum products, which increases the risk of intoxication. 13% of producers incinerate or bury the packages, while 8% of them abandon the packages in nature. The environmental and health risks associated with the use of these essential but dangerous products are increasing. The Fig. 8 illustrates a form of use of pesticide packaging in the study environment.



ND = No Discomfort; Vo/Na = Vomiting or Nausea; He = Headache; Co= Cold; VD = Vision Disorders; AP= Abdominal Pain; RD = Respiratory Difficulty; SD= Skin Disorders; FS= Fatigue and Sweat; Ve=Vertigo; Co-Ve = Cold and Vertigo; F-S-D= Fatigue, Sweat and Dizziness; SD-FS = Skin Disorders, Fatigue and Sweating.

Fig. 9. Discomfort felt by producers after application of chemical inputs.

Source: Field survey, July 2023

Health effects linked to the use of chemical agricultural inputs

According to the surveyed producers, two cases of poisoning were recorded in Tchaourou district in 2010, resulting in 11 deaths and 1 survivor. The health zone statistician, citing poor archiving practices before 2018, provided statistical data for 2021, which included five (5) cases of intoxication, resulting in 2 deaths and three (3) survivors. In 2022, there were eleven (11) cases, with four (4) resulting in deaths. Fig. 9 illustrates the various discomforts experienced by producers following the application of chemical inputs.

Analysis of Fig. 9 indicates that the use of chemical agricultural inputs results in various discomforts among producers. Specifically, 3% of respondents report no discomfort after use, while 5% experience nausea or vomiting. Headaches are reported by 6% of respondents, and 11% suffer from a cold. Vision problems and abdominal pain each affect 5% of the respondents. Additionally, 10% report skin disorders, and 12% experience fatigue and sweating. Dizziness occurs in 15% of the cases, while 4% report having both a cold and dizziness. Furthermore, 12% experience a combination of fatigue, sweating, and dizziness, and 6% report simultaneous skin disorders, fatigue, and sweating.

Discussion

The pesticide and fertilizer lobby often touts its contributions to agriculture, *yet* it conceals the detrimental consequences it brings about (Blanchon, 2021). Public health concerns and controversies over pesticide use have been long-standing, gaining significant attention over the last decade. Notably, the 2017 Monsanto Papers scandal involving glyphosate led the European Parliament, leveraging evidence from the "Monsanto Papers," to advocate for the non-renewal of glyphosate's authorization in Europe (Le Monde, 2022). The issue intertwines scientific and political dimensions, with implications for Benin as well. Emphasizing public health is crucial, as the problem affects not only agricultural workers but also residents of agricultural areas, warehouse employees, and consumers of agricultural, animal, or aquaculture products.

In the commune of Tchaourou, low education levels and lack of training among producers are primary factors contributing to the excessive use of phytosanitary products. Similar findings have been reported in studies from Benin (Ahouangninou *et al.*, 2011), Burkina Faso (Son *et al.*, 2017), Côte d'Ivoire (Wognin *et al.*, 2013), Senegal (Badiane, 2004), and Togo (Kanda *et al.*, 2013). Authors such as Adechian *et al.* (2015) have highlighted the informal supply channels established in Tchaourou, a situation also noted in Burkina Faso (Gomgnimbou *et al.*, 2009; Son *et al.*, 2017).

Phytosanitary products are often stored without authorization, violating United Nations Industrial Development Organization (UNIDO) guidelines. Our study reveals that 28% of producers are unaware of the risks associated with chemical inputs, echoing Togbé *et al.* (2012) who found total ignorance among farmers regarding the health hazards of phytosanitary products. Immediate effects such as skin irritations, headaches, nausea, and dizziness were recorded among those directly exposed, similar to findings by Gouda *et al.* (2018) in the cotton basin, where 85% of producers reported discomfort. The harmful nature of active substances explains these ailments, with similar issues reported by Gomgnimbou *et al.* (2009) and Son *et al.* (2017) among cotton and vegetable producers in Burkina Faso. The health of producers is further compromised by the lack of personal protective equipment during pesticide preparations and applications. Long-term exposure can lead to severe conditions such as neurological disorders, fertility issues, congenital abnormalities, cancers, and endocrine disorders (Jouzel and Prete, 2022). Blanchon (2021) notes that even low pesticide exposure can cause significant health issues, including male infertility, cancers, and fetal harm, increasing vulnerability among children, pregnant women, and the elderly due to their less developed immune systems or different metabolisms.

Empty pesticide packages are often discarded in nature post-treatment, with some being reused, a practice confirmed by studies in Côte d'Ivoire (Doumbia and Kwadjo, 2009), Togo (Kanda, 2011), and Burkina Faso (Son *et al.*, 2011). Reusing pesticide containers for food storage, even after washing, poses severe health risks.

Biodiversity is also threatened by pesticides (Blanchon, 2021). The Food and Agriculture Organization (2021) reports that systemic insecticides from the neonicotinoid group negatively affect pollinators' reproductive potential and contribute to the global decline of honeybees and wild bees, reducing their pollination function. One-third of birds in agricultural environments have disappeared in less than 30 years, 38% of bat populations in 10 years, and nearly 80% of insects have suffered a similar fate (FAO, 2021).

For plants associated with cultivated agricultural environments, Chaboussou (2020) demonstrates that it is the very physiology of the cultivated plant that is disrupted by pesticides, making it more vulnerable to aggressors. He shows that the massive use of pesticides creates fragilities in plants that will lead to even greater use of these toxins in an attempt to reduce the new damage caused by this fragility. The figures are no more reassuring, with 51% considered in a precarious situation when 7% have disappeared (Blanchon, 2021).

Conclusion

In conclusion of our study involving 250 producers utilizing chemical agricultural inputs, a definitive conclusion emerges: pesticides pose a global threat associated with the collapse of biodiversity. Various harmful or toxic active substances are employed by farmers in the commune of Tchaourou to enhance their productivity. Our findings indicate that from the supply chain to the management of empty packages, best practices are not being followed. Notably, 76% of producers overuse pesticides, and 16% of them take no protective measures before treating the fields, which severely exposes the Beninese and Tchaourou populations to health risks such as nausea or vomiting (5%), headaches (6%), colds (11%), abdominal pain (5%), and various other discomforts, including recorded fatalities (four deaths in 2022). An integrated approach combining strict regulation, the adoption of sustainable agricultural practices, and heightened awareness is essential to ensure long-term, sustainable, and safe agriculture. It is imperative to recognize the use of pesticides as a significant public health issue before facing irreversible damage.

Recommendation(s)

In the face of the perversion of sanitary and environmental risks associated with the use of chemical agricultural inputs, various solution approaches have been considered at different levels.

1. Regulation and control: Strict regulations are necessary to monitor the use of pesticides, their formulation, and their distribution.
2. Use of alternative practices: Encourage sustainable agricultural methods such as organic farming, crop rotation, integrated pest management, and other techniques that minimize dependence on chemical pesticides.
3. Training and awareness: It is essential to train farmers on the safe use of pesticides, as well as on the associated risks and good agricultural practices, so that they are aware of the use of personal protective equipment.

References

Adechian SA, Baco MN, Akponikpe I, Toko II, Egah J, Affoukou K. 2015. Les pratiques paysannes de gestion des pesticides sur le maïs *et* le coton dans le bassin cotonnier du Bénin. VertigO - la revue électronique en sciences de l'environnement **15(2).** https://doi.org/10.4000/vertigo.16534

Agbohessi T, Imorou T, Kestemont P. 2011. Caractérisation des pesticides chimiques utilisés en production cotonnière *et* impacts sur les indicateurs économiques dans la commune de Banikoara au nord du Bénin. International Journal of Biological and Chemical Sciences **5(5),** 1828-1841.

Ahouangninou C, Fayomi BE. 2011. Évaluation des risques sanitaires *et* environnementaux des pratiques phytosanitaires des producteurs maraîchers dans la commune rurale de Tori-Bossito (Sud-Bénin). Cahiers Agricultures **20(3),** 216-222. https://doi.org/10.1684/agr.2011.0485

Ake A, Amian ARF, Yeo GM, Etchian AO, Yao LA, Yapo AF, Ble MC. 2023. Analyse socio-démographique des agriculteurs de la zone de Marnagedu Lac Buyo (Côte d'Ivoire) *et* risques potentiels liés à l'utilisation des pesticides. ESI Preprints. https://doi.org/10.19044/esipreprint.5.2023.p1

Amadou SM, Agbo M. 2017. Population *et* développement dans la commune de Tchaourou: l'importance d'un système d'informations statistiques. https://scienceetbiencommun.pressbooks.pub/tchaourou/back-matter/conclusion

Badiane M. 2004. Utilisation des pesticides dans le système maraicher périurbain: variation annuelle *et* impacte sur la santé des populations. Thèse de doctorat en médecine vétérinaire, Dakar, EISMV.

Blanchon E. 2021. Les effets des intrants sur la santé *et* l'environnement. https://www.lyceecaraminot.fr/upload/2020_2021/Actualites/Articles_scientifiques/BLANCHON--PAYSANT_Elie_20-05.pdf

Chaboussou F. 2011. Les plantes malades des pesticides. https://www.decitre.fr/livres/les-plantes-malades-des-pesticides-9782868199324.html

Coulibaly M. 2022. Analyse des risques sanitaires liés à l'activité de maraichers dans la vallée de Téguéré à Korhogo (nord-Côte d'Ivoire). Lett. Sci. Soc. Hum., **38,** 227-247.

Dagnelie P. 1998. Statistique théorique *et* appliquée. Tome 1: statistique descriptive *et* bases de l'inférence statistique. De Boeck *et* Larcier, Bruxelles.

Doumbia M, Kwadjo KE. 2009. Pratiques d'utilisation *et* de gestion des pesticides par les maraichers en Côte d'Ivoire: cas de la ville d'Abidjan *et* deux de ses banlieues (Dabou *et* Anyama). Journal des Biosciences Appliquées, **18,** 992-1002.

Dutoit F. 2023. Agriculture face à deux défis: le climat *et* l'explosion démographique. https://fr.linkedin.com/pulse/agriculture-face-%C3%A0-deux-d%C3%A9fis-le-climat-et-lexplosion-freddy-dutoit

FAO. 2021. Détoxifier l'agriculture *et* la santé des pesticides: détoxifier l'agriculture *et* la santé des pesticides extrêmement dangereux: un appel à l'action. Organisation mondiale de la Santé. https://doi.org/10.4060/ca6847fr

Gomgnimbou A, Savadogo P, Nianogo AJ, Millogo-Rasolodimby J. 2009. Usage des intrants chimiques dans un agrosystème tropical: diagnostic du risque de pollution environnementale dans la région cotonnière de l'est du Burkina Faso. Biotechnologie, agronomie, société *et* environnement **13(4),** 499–507.

Gouda AI, Imorou TI, Salami SD, Richert M, Scippo ML, Kestemont P, Schiffers B. 2018. Pratiques phytosanitaires *et* niveau d'exposition aux pesticides des producteurs de coton du nord du Bénin. Cahiers Agricultures **27,** 65002. https://doi.org/10.1051/cagri/2018038

IGN-Benin. 1992. Carte topographique du Bénin.

Jouzel JN, Prete G. 2022. Pesticides *et* santé humaine. Pesticides *et* santé humaine. Études: revue de culture contemporaine **4297,** 45-56. https://doi.org/10.3917/etu.4297.0045

Kanda M, Djaneye-Boundjou G, Wala K, Gnandi K, Batawila K, Sanni A, Akpagana K. 2013. Application des pesticides en agriculture maraîchère au Togo. VertigO - la revue électronique en sciences de l'environnement **13(1).** https://doi.org/10.4000/vertigo.13456

Kanda M. 2011. Agriculture maraîchère au Togo: analyse systémique *et* environnementale. Thèse de doctorat, Université de Lomé, Togo.

KpanKpan KG, Yao BL, Diemeleou AC. 2019. Pratiques phytosanitaires en agriculture périurbaine *et* contamination des denrées par les pesticides: cas des maraîchers de Port-Bouët (Abidjan). Journal of Animal and Plant Sciences **41(1),** 6847–6863.

Le Monde. 2021. La face cachée des engrais azotés. https://www.lemonde.fr/planete/article/2021/04/08/pollution-la-face-cachee-des-engrais-azotes_6075943_3244.html

Le Monde. 2022. Quelles suites depuis l'enquête « Monsanto Papers », sur les pratiques de l'entreprise pour défendre le glyphosate? https://www.lemonde.fr/planete/article/2022/09/16/quelles-suites-depuis-l-enquete-monsanto-papers_6141912_3244.html

Lehmann E, Oltramare C, Nfon Dibié JJ, Konaté Y, De Alencastro LF. 2016. Assessment of occupational exposure to pesticides with multi-class pesticide residues analysis in human hairs using a modified QuEChERS extraction method: case study of gardening areas in Burkina Faso. In: Annual Meeting of the International Association of Forensic Toxicologists (TIAFT), Brisbane, Australia.

MAEP. 2020. Rapport des performances du secteur agricoles au Bénin. https://apidsa.agriculture.gouv.bj/public/storage/uploads/6iObYAEkbAsCZ2g0UZ3rcuxzaGgHtKsWcKJ6B1OE.pdf

Ousmane K. 2006. Monographie de la commune de Tchaourou. https://www.yumpu.com/fr/document/read/35587589/monographie-de-la-commune-de-tchaourou-association-nationale

Son D, Somda I, Legreve A, Schiffers B. 2011. Pratiques phytosanitaires des producteurs de tomates du Burkina Faso *et* risques pour la santé *et* l'environnement. Cahiers Agricultures **26,** 25005. DOI: 10.1051/cagri/2017010.

Soulé BG. 2012. Impact du Commerce Agricole sur l'Emploi au Bénin. https://www.ilo.org/fr/publications/impact-du-commerce-agricole-sur-lemploi-au-benin

Soumaré M, Havard M, Bachelier B. 2020. Le coton en Afrique de l'Ouest *et* du Centre: de la révolution agricole à la transition agro-écologique. Cahiers Agricultures **29,** 37.
DOI: 10.1051/cagri/2020037

Togbé CE, Zannou ET, Vodouhê SD, Haagsma R, Gbèhounou G, Kossou DK, Van-Huis A. 2012. Technical and Institutional Constraints of a Cotton Pest Management Strategy in Benin. NJAS-Wageningen Journal of Life Sciences **60,** 67-78.

Wognin AS, Ouffoue SK, Assemand EF, Tano K, Koffi-Nevry R. 2013. Perception des risques sanitaires dans le maraîchage à Abidjan, Côte d'Ivoire. International Journal of Biological and Chemical Sciences, **7(5),** 1829-1827.
DOI: 10.4314/ijbcs.v7i5.4.

Wolf SA, Wood SD, Lefèvre M. 2023. L'agriculture de précision: légitimation environnementale, marchandisation de l'information et coordination industrielle. Écologie & Politique **1(66),** 30-52.