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# Characterization of herbicide use practices in cereal agroecosystems in western Burkina Faso

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KEYWORDS

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Agricultural practices

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**ABSTRACT**

The use of pesticides often leads to environmental contamination above acceptable levels. The level of contamination is related to poor pesticide application practices, in addition to the properties of pesticides and soil characteristics. The primary objective of this study was to characterize herbicides and their application practices in cereal crops in the regions of Hauts-Bassins, Sud-Ouest, Cascades, and Boucle du Mouhoun in Burkina Faso. A semi-structured questionnaire was used to collect and extract data from 617 cereal farmers in the four regions. During the survey, the identified herbicides were characterized using pesticide property databases. The survey shows that most cereal farmers in the regions are illiterate (58.18%) and have not received any training in pesticide use (84.28%). Only a small percentage of farmers (1.3%) consult technical services for the selection of herbicides to be used. The survey also revealed that 60% of farmers leave empty herbicide containers in the wild, 39.93% use water sources to clean sprayers, and 17.83% use them to prepare the spray mixture. A total of 25 active ingredients were identified in 117 commercial herbicide products with a total use of 8100 litres and 280 kg. Of the listed herbicides, 45.37% were not approved by the Sahel Pesticide Committee (CSP). Among the non-approved herbicides, 27.78% contained paraquat, atrazine, and acetochlor, which the CSP bans. The

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study shows that farmers do not follow good practices when using herbicides, which can contaminate different environmental compartments and cause harmful effects to non-target organisms.

## 1 Introduction

Agriculture is the main activity for 56.2% of the population in Burkina Faso (INSD 2022), focusing on cereal crops. However, the country faces challenges meeting its food crop needs due to population growth and production constraints (Ouédraogo et al. 2009; MAAH 2018). Various pests associated with cereal crops are the main production constraints, causing losses of up to 40% per year (Mahmood et al. 2016). To combat this, farmers use synthetic chemical pesticides, which are applied uncontrolled and in large quantities yearly (Bernhardt et al. 2017). This is because of the increased cultivated area and productivity, the drain on farm labour (Gianessi 2013; Houngnihin et al. 2021), and the high cost of mechanical weeding (Olina Bassala et al. 2015). As a result, farmers are turning to chemical weed control with herbicides (Olina Bassala et al. 2015). However, the excessive use of phytosanitary products can cause harm to living organisms (MAAH 2020), the environment, and ecosystems (GRAAD 2017; Tchamadeu et al. 2017; Gbombele et al. 2019). Herbicide formulations contain highly toxic active molecules, and 80-90% of these active ingredients are transferred to the non-target environment during spraying (van der Werf 1997), leading to ecosystem degradation. Poor farming practices and non-compliance with pesticide use conditions have been identified (FAO 2002; Compaore et al. 2019). The most common poor practices used by farmers include repeated treatments, overdosing, mixing of several pesticides when spraying, washing of sprayers at water points, use of unregistered or banned products, and poor management of empty containers (Gomgnimbou et al. 2009; Tchamadeu et al. 2017; Bayili et al. 2019). Studies on pesticides have mainly focused on cotton-growing areas (Bayili et al. 2019), market gardening (Tarnagda et al. 2017; Ngakiama et al. 2019), and peri-urban dam reservoirs (Bèkouanan 2018). Limited data is available on herbicide use practices in cereal crops, which occupy most of the agricultural land in Burkina Faso. This study aims to characterize herbicides and their use practices in cereal crops in the Hauts-Bassins, Sud-Ouest, Cascades, and Boucle du Mouhoun regions of Burkina Faso.

## 2 Materials and Methods

### 2.1 Study Sites

These field studies were carried out in the Hauts-Bassins, Sud-Ouest, Cascades, and Boucle du Mouhoun regions in the western part of Burkina Faso (Figure 1). These regions cover both Sudanese and Sudano-Sahelian climates, with the latter being the wettest area in the country. These four regions account for 41% of

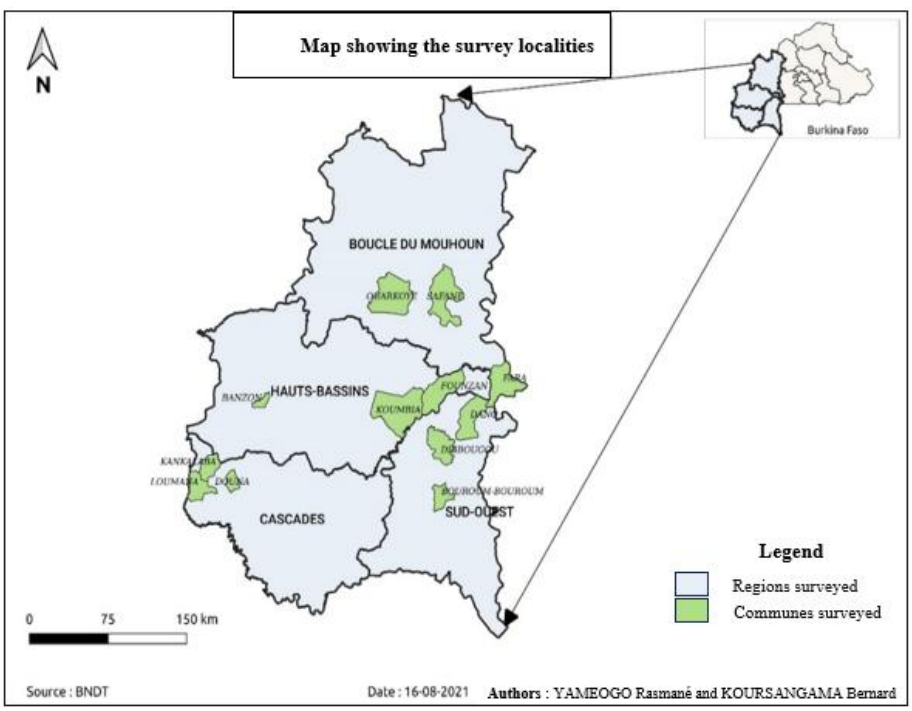


Figure 1 Indicative map of the study area

the country's total cultivated land (MAFAP 2013), which has led to a significant increase in the use of phytosanitary products. The survey covered three communes in each region, comprising 12 communes. During the study period (2020-2021), the communes in the study area received an average rainfall of 877 mm, varying from 640.5 mm to 1223.25 mm.

### 2.2 Human study population and inclusion criteria

The survey only included farmers who grow cereal crops. To be eligible, they must have at least one cereal field within the survey area and used herbicides in the 2020-2021 crop year. The selection process involved random selection from those who met the criteria and volunteered. In each of the 12 communes, a minimum of 50 farmers were selected.

### 2.3 Surveys of farming practices and characterization of herbicides used

This survey aimed to determine which herbicides are used in cereal growing areas and how they are applied. Each farmer was provided with a semi-structured questionnaire that covered various topics, including sociodemographic information, general farm data, herbicide identification, herbicide use conditions and practices, and environmental risk perception. To get a better understanding of the herbicides being used, a literature search was conducted using several sources, such as the list of pesticides registered by the CSP, the Pesticide Properties Database/Biopesticide Database (PPDB/BPDB) (Lewis et al. 2016), and pesticide directories from neighbouring countries like Ghana and Côte d'Ivoire, which don't have the same registration system as Burkina Faso.

### 2.4 Data Analysis

Survey data was collected using a paper questionnaire and entered into Microsoft Excel 2016. The analysis was descriptive, with frequencies and proportions calculated using R (version 4.0.1, 06-06-2020), and graphs were generated using Microsoft Excel 2016.

## 3 Results

### 3.1 Sociodemographic and farming characteristics

In total, 617 farmers were interviewed in the 12 communes, and 88% were men. The age of the respondents varied from 18 to 85 years, with a median of 41 years. The majority of respondents, about 67.25%, fell within the age range of 35 to 55 years. As for pesticide use practices, 84.28% of farmers received no training. Moreover, 58.18% of the farmers were illiterate, while 28.69% had only primary education as their highest level of education, as shown in Table 1. Regarding water availability, 77.8% of the farmers stated that they had at least one water point close to their farms, and the average distance from them was 50 meters. These water points included wells (24.79%) and streams (24.2%). Other water points identified included boreholes, rivers, gullies, puddles, and ponds, with proportions ranging from 4.8% to 19%. Cereal production was the most common among the crops grown in the study area. Among the major cereals, maize was grown on 1222 ha, sorghum on 552.9 ha, rice on 324.8 ha, and millet on 203.2 ha.

### 3.2 Agricultural Practices

The study analyzed the farming practices related to the use of herbicides. It focused on the source of supply, choice of herbicides, management of empty packaging, handling of residual spray liquid, mixing of several herbicides, sprayer used, where it is washed, resumption of treatment, and perception of the risk of environmental contamination. The survey revealed that 89.87% of cereal farmers purchase herbicides from the local market, 5.35% from authorized dealers, and 4.48% from crop phytopharmaceutical companies. Only 1.3% of farmers consult technical services while selecting herbicides. 79.58% of farmers prepare the spray mixture on the field, 17.83%

Table 1 Distribution of cereal farmers by sociodemographic characteristics

| | Social status | Frequency (%) |
|---|---|---|
| Sex | Men | 88 |
| | Women | 12 |
| Training in the use of pesticide status | Untrained | 84.28 |
| | Trained | 15.72 |
| Education level | Illiterate | 58.19 |
| | Primary | 28.69 |
| | Secondary and above | 13.13 |
| Ages | 18 to 35 | 21.87 |
| | 36 to 55 | 67.25 |
| | Over 55 | 10.85 |

near water sources, and 2.59% at home. Moreover, 98% of farmers use a backpack sprayer to treat their fields. Regarding cleaning equipment, 39.93% of farmers clean it at water sources, 38.09% in the field, and 21.98% at home (Figure 2).

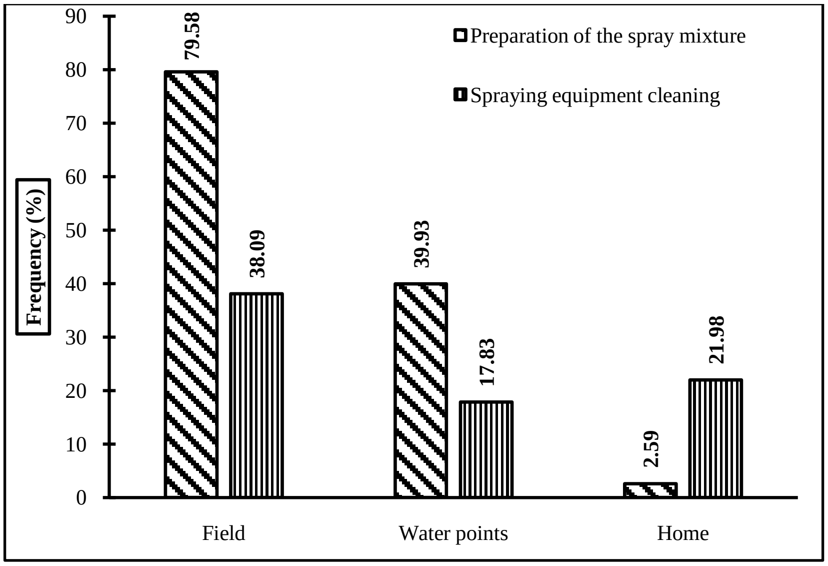


Figure 2 Distribution of farmers according to where the herbicide mixture is prepared and where the spraying equipment is washed

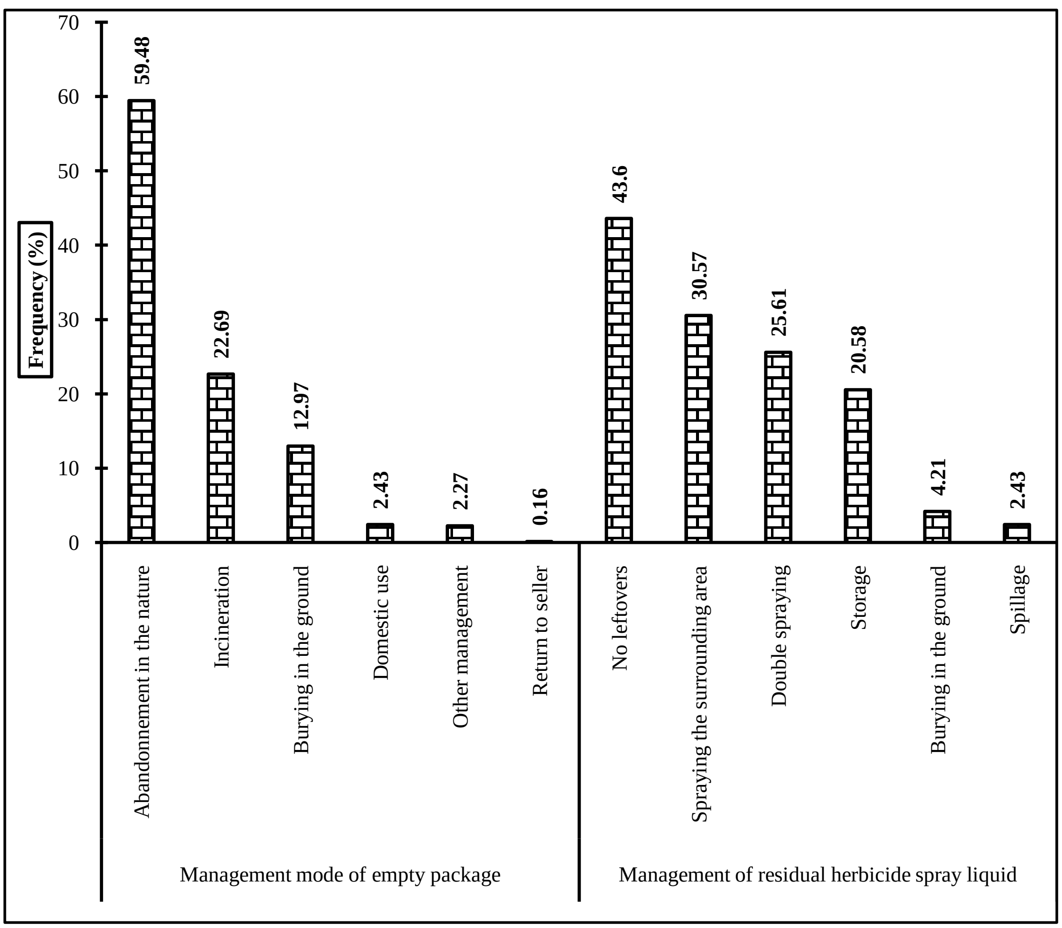


Figure 3 Distribution of farmers by management mode for empty packaging and residual herbicide spray liquid

After treatment, 60% of the farmers disposed of empty herbicide containers in the wild, 13% buried them, and 23% incinerated or used them for domestic purposes (Figure 3). In 20.58% of the cases, the remaining spray mixtures are stored for later use, and 25.61% of farmers do a second round of spraying (Figure 3). In terms of environmental risks, 70.18% of the farmers were aware of the herbicide contamination risk, while 30% said otherwise. Out of the surveyed farmers, 18.64% had mixed different herbicide formulations for spraying, and 48.69% had done so for efficacy reasons. During the campaign, 23.5% of farmers resumed spraying.

### 3.3 Knowledge about herbicides used

A study has identified 117 commercial herbicides formulated from 25 active ingredients in the four regions surveyed (Figure 4). Glyphosate, nicosulfuron, atrazine, and 2,4-D are the most commonly used active ingredients found respectively in 44.44%, 12.82%, 6.84%, and 5.98% of the formulations (Figure 4). Of these herbicides, 45.37% are not approved, and 27.78% of these non-approved herbicides contain active ingredients banned by the Sahel Pesticide Committee. Additionally, 91.22% of the herbicides are liquid, with the most common formulations being concentrated soluble (SL) at 59.23% and concentrated suspension (SC) at 17.53%. These herbicides are imported from eight countries. The study found that 51.96% of the commercial herbicide formulations were of Chinese origin, 24.73% were from France, and 9.84% were from Ghana (Figure 5). The herbicide formulations belong to classes III (66%), II (18%), and U (8%) of the WHO toxicity classification (Figure 6). Farmers surveyed used approximately 8100 L and 280 kg of herbicides during the study crop year.

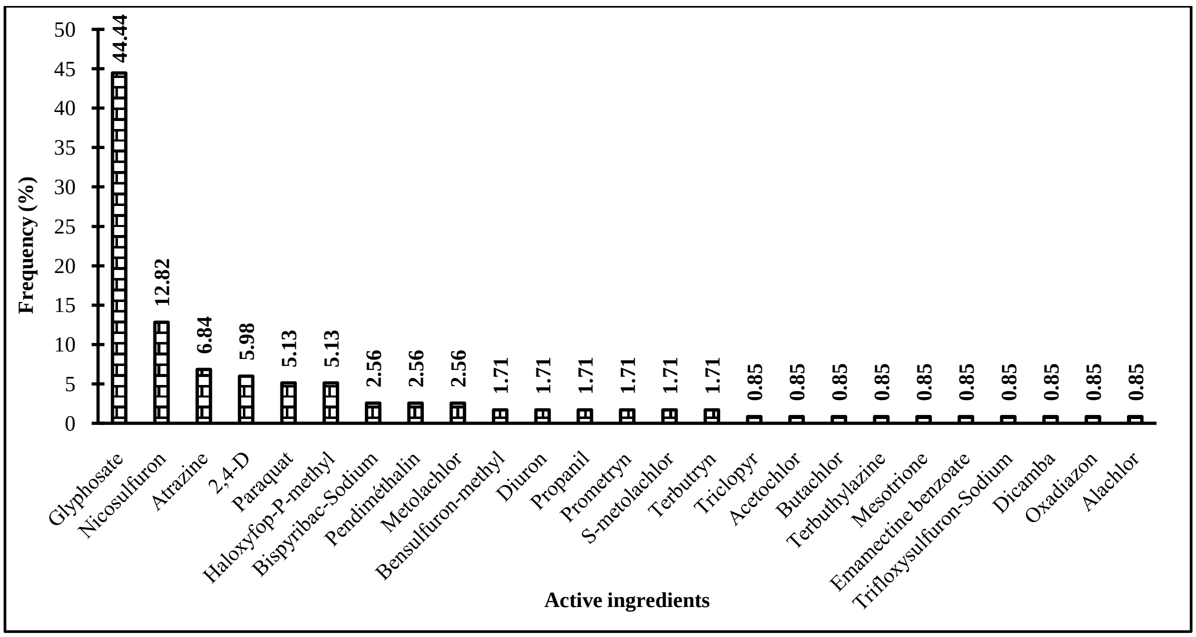


Figure 4 Distribution of herbicide commercial formulations by active ingredients

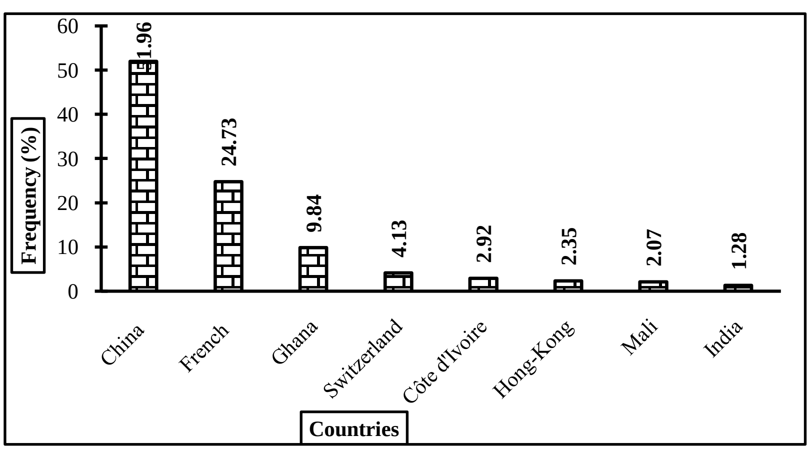


Figure 5 Distribution of herbicide commercial formulation by country of origin

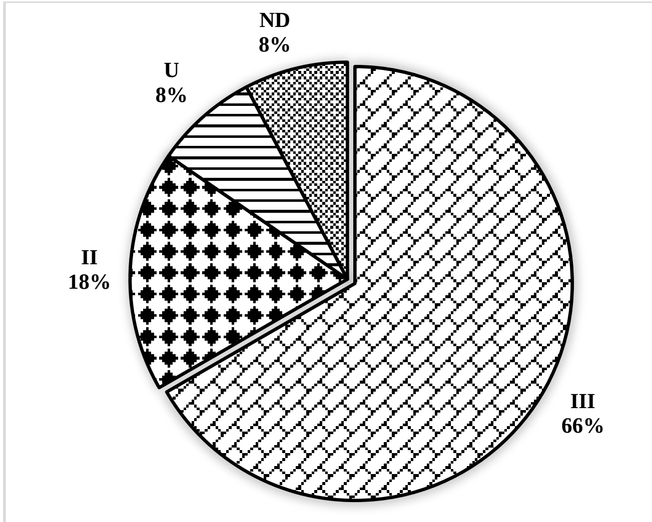


Figure 6 Distribution of herbicide commercial formulations by WHO class.

**4 Discussion**

According to a recent survey, adults with low literacy levels mostly engage in cereal farming. This finding is consistent with a study by Compaore et al. (2019) on the rice-growing lowlands of Dano in southern Burkina Faso, where they found that 61% of the survey population was illiterate. Other authors have made similar observations regarding illiteracy in non-cereal crops (Lelamo et al. 2023). The survey also revealed that many cereal farmers have not received any training on proper pesticide use. This differs from the findings of studies on cash crops like cotton and coffee, where almost all farmers are trained or have access to information on safe pesticide use (Ouédraogo et al. 2009; Lelamo et al. 2023). The lack of training for cereal farmers may be due to low funding for the food sector in favour of export crops. However, cereal farmers' illiteracy and lack of knowledge suggest a limited understanding of pesticide use instructions (Compaore et al. 2019). Maize and sorghum are the two main cereals grown in terms of area. However, the results obtained from the four regions vary slightly from the national agricultural statistics 2019, where the sorghum area is slightly higher than maize (ISND 2019). While maize cultivation increases the demand for pesticides (MAFAP 2013), sorghum is often cultivated without crop rotation, encouraging the proliferation of weeds. Moreover, using fertilizers tends to benefit the growth of weeds, increasing the need for herbicides (Aubertot et al. 2005).

According to this survey, cereal farmers receive little technical assistance when selecting herbicides. As most of these farmers are illiterate, they choose the herbicides themselves. This is also the case in vegetable production in the centre-north of the country, where farmers randomly choose pesticides or base their choices on their own experience (Ouédraogo et al. 2021). This practice is also prevalent in other member countries of CILSS, which is one of the reasons why pesticides are misused (Adjovi et al. 2021). According to Bayili et al. (2019), local pesticide dealers are not trained in the management and use of pesticides. These findings could explain why banned or unapproved products are used, and treatments are misused and resumed. These practices are potentially dangerous for the environment.

Many farmers dispose of their herbicide containers in the wild, while others apply a second dose if there are any residual herbicide preparations, and some mix different herbicide formulations for more efficient weed control. These practices, reported in cotton-growing areas previously (Tapsoba and Bonzi 2006), could result in an accumulation of pesticide active ingredients in the environment. This may cause toxic molecules to become readily available for transport through runoff to other environments. Since most farmers report having water retention areas around their fields, with a median distance of about 50 m, the aquatic environment is the primary destination for these herbicide surpluses. Earthworms and amphibians living in soil and water, respectively, could also be affected by the migration of herbicides into their habitats (Boileau 2015; Pelosi et al. 2021). Farmers washing sprayers on the ground in fields and near water reservoirs further increases the risk to aquatic and terrestrial organisms. This practice directly leaches many toxic molecules into the soil and water, habitats for various non-target organisms, including disease vectors. Agricultural pesticides have been identified by Hien et al. (2017) and Diabaté et al. (2002) as a contributing factor to the development of resistance in malaria vector mosquito populations in Burkina Faso.

One hundred and seventeen commercial herbicide specialities formulated from 25 active ingredients were identified in the four regions surveyed. These herbicides were sourced from eight countries, with China being the biggest source, followed by France and Ghana. This diversity of origin could make the task of controlling herbicides more complicated. For instance, some unauthorized pesticides with questionable quality are fraudulently imported into Burkina Faso from neighbouring countries (Paré and Toé 2011). About half of the herbicides identified were unauthorized, and some contained active substances that the CSP banned due to their environmental toxicity, including paraquat, atrazine, and acetochlor (CSP 2014). Glyphosate was the most commonly used active ingredient in herbicide formulations, as observed in previous studies by Bayili et al. (2019) and Le Du-Carrée (2021). However, the ecotoxicological risk of glyphosate remains to be elucidated, as Le Du-Carrée (2021) suggests that it could disrupt embryonic development in fish following re-exposure to parental compounds. Additionally, the greater the number of molecules introduced, the greater the potential for environmental contamination (Mamy et al. 2008) and the greater the possibility of synergistic toxicity to non-target organisms.

Cereal farmers prefer liquid formulations because they are easier to mix, store, and transport (Fishel 2019). However, these formulations pose a relatively high risk of environmental contamination. This is because they are highly concentrated in active ingredients, and a simple dosing error could result in overdosing. They also have a high potential for drift and are difficult to target (Fishel 2019). Furthermore, spraying is almost exclusively done with backpack sprayers, which, according to the Food and Agriculture Organization of the United Nations (FAO), are used under high pressure, resulting in significant drift due to the production of fine droplets (FAO 1998).

## Conclusion

This study in Burkina Faso identified several herbicides commonly used in the cereal-growing regions of Hauts-Bassins, Sud-Ouest, Cascades, and Boucle du Mouhoun. The investigation has found that the supply chain for these products is not entirely regulated due to their diverse origins. Local farmers and retailers often lack training and do not consult technical services, which leads to poor management of empty packaging and the use of unauthorized or banned products. Combined with the number and chemical characteristics of the herbicides used, these practices pose a risk of environmental contamination. This contamination could affect non-target organisms, including disease vectors whose life cycle partly occurs in contaminated waters.

## Conflict of Interest

The authors declare that there is no conflict of interest.

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