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Cholinesterase Activity as an Indicator of Health Risks among Kou Valley Farmers

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Abstract

Introduction: Pesticides are currently an essential component of agricultural production techniques for controlling pests and weeds. In Burkina Faso, non-compliance with good practice in the use of pesticides poses a real health problem for the population. This study examines the health risks associated with pesticide management in rice-growing areas. **Material and Methods:** A field survey was conducted in Bama, involving farmers, focusing on their socio-demographic characteristics, pesticide usage, and health effects. Cholinesterase levels were measured in subsample of farmers using a portable device. Data were analysed using Microsoft Excel, calculating means and percentages for various practices. Health consultations, protection methods, and pesticide management were studied. Erythrocyte acetylcholinesterase activity was compared before and after treatment. Data were categorised into classes based on inhibition levels, and correlation analyses determined relationships between variables such as age, years of experience, and cholinesterase activity. **Results:** The results indicate that rice cultivation is mainly carried out by a fairly young population, with nearly 63% being under the age of 50. Common poor practices in pesticide use include improper storage and reuse of leftover pesticides. Seven types of pesticides were identified, including organophosphates such as glyphosate, which was used in 26.7% of cases. This organophosphate has resulted in class B poisoning, causing a 30% - 50% reduction in erythrocyte cholinesterase activity. The health effects of pesticide use are felt by agricultural farmers through various symptoms of poisoning. **Conclusion:** To reduce the occurrence of pesticide poisoning, it is essential to launch information and awareness campaigns among the population and farmers to promote safe practices in pesticide use in Bama, Burkina Faso.

Keywords

Pesticides, Environmental, Sanitary, Risk, Acetylcholinesterase, Farmers, Bama, Burkina Faso

1. Introduction

Agriculture is crucial for promoting growth and reducing poverty in Africa. It supports 80% of the African population, contributes 35% to African gross domestic product, and employs 65% of the economically active population [1]. Four cereals, namely wheat, millet, maize, and rice, are widely cultivated worldwide [1]. However, pests and crop diseases pose a significant threat to agriculture, in addition to climatic hazards. Pests can cause significant damage to crops, with destruction amounting to 15% of production each year in Burkina Faso [2]. Toé *et al.* reported that in some cases, pests can result in a loss of production of over 30% [3] [4]. The use of chemical pesticides can effectively mitigate this damage by reducing or even eliminating crop damage caused by pests. Phytosanitary treatments are a key factor in agricultural development [4]. Pesticides are used to control crop pests, particularly those affecting cash crops, sugar cane, market gardening, and rice crops [5] [6]. They are designed to prevent or combat plant diseases, pests, and weeds while safeguarding crops [7]. Chemical herbicides have become a popular choice for farmers to avoid schedule delays and streamline maintenance procedures [8]. Agriculture, which employs 86% of the population and contributes roughly 40% of the gross domestic product [9], faces many challenges that require solutions. Currently, there are almost 185 commercial products available in Burkina Faso, containing approximately one hundred active ingredients. Of these, 75% have insecticidal, acaricidal, or nematocidal properties. Organophosphates and pyrethroids account for about 65% of the active ingredients in the products available on the market.

It is important to note that the misuse and uncontrolled use of pesticides can have serious consequences for human and animal health, as well as the environment. Pesticides pose hazards in three areas: environmental pollution and toxicity [10] [11], toxicity to consumers due to the existence of toxic residues [12], and toxicity to farmers and phytosanitary workers [13] [14]. It is crucial to note that pesticides can harm human health, causing symptoms such as nausea, vomiting, dizziness, sterility, birth defects, neurological and reproductive disorders, and even cancer in certain cases. Therefore, the use of pesticides should adhere to good agricultural practices. In Burkina Faso, several studies and reports have highlighted the widespread non-adherence to good agricultural practices by farmers [15] [16]. The objective of this study is to reduce the risks associated with pesticide use. Safe handling of pesticides is a crucial mission that requires the collective effort of all stakeholders involved in the regulation, production, distribution, and usage of these substances. The goal is to protect the health of users and consumers and preserve the integrity of the environment, by adopting a "One Health" approach. The study aimed to measure cholinesterase levels among rice farmers in Bama commune, an area known for rice cultivation, using a portable device (Test-mate Model 400 EQM®) associated with organophosphate poisoning. It is possible that changes in the environment and farming techniques since 1970 could have played a role in pesticide poisoning. This study aims to improve the well-being of communities and protect the environment by reducing the health and ecological risks associated with pesticide use in rice fields in Burkina Faso.

2. Material and Methods

2.1. Study Area

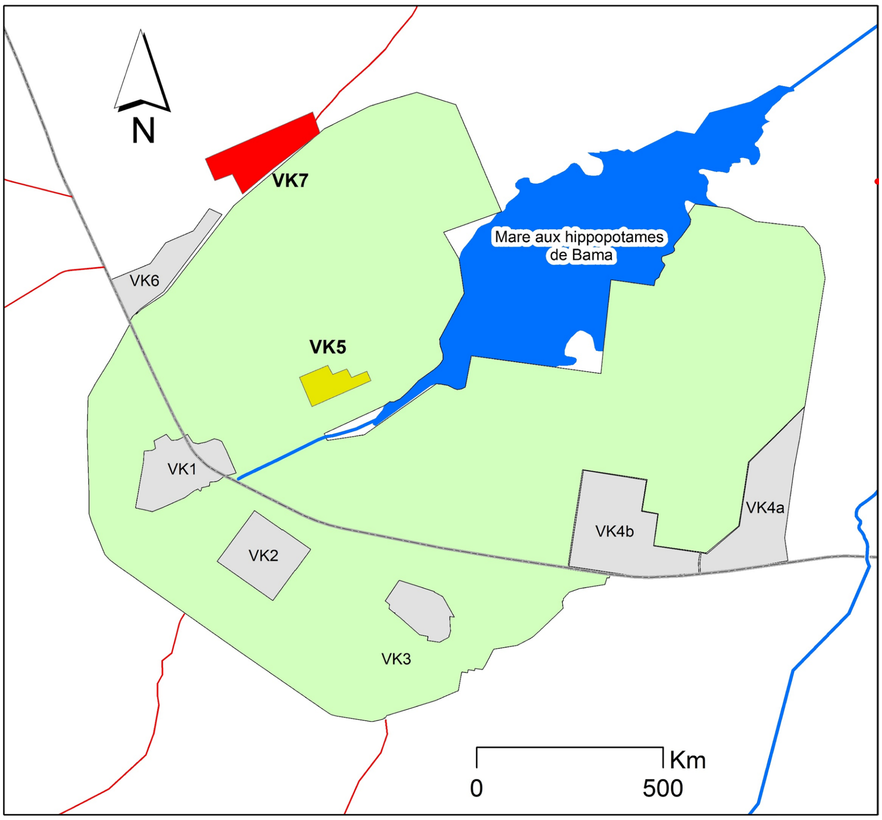

Figure 1. Study area.

The study was carried out in Bama, located in Kou Valley, a region in the southwest of Burkina Faso where rice cultivation is prevalent. The rice-growing area is composed of seven sectors in the health district of Dandé, as shown in "**Figure 1**". Vallée du Kou has an estimated population of 22,244 as of 2020. It is situated in the Sudan area, which is characterised by a dry season from November to April and a rainy season from May to October, with an average annual rainfall of 1200 mm. Rice has been the primary crop grown in this plain since the 1970s, with two crop cycles per year that require irrigation of the rice plains from January to May and from June to November. Rice farming requires minimal use of insecticides, although neighbouring fields often use them extensively to manage pests that affect cotton and vegetable crops. The irrigation system used in rice paddies creates permanent and productive mosquito breeding sites due to the constant supply of water. In the plains where rice is grown, the mainstream serves as the primary source for irrigation and drainage of plots. In the event of a blockage downstream in an irrigation channel, the water level will rise. To allow water to enter the plot, a bund is breached. Data collection occurred from August to October 2022, during the rice-growing season. Two types of data: survey quantitative data and biological data from finger-prick blood samples.

2.2. Quantitative Survey in Farmers from Rice-Growing Areas

Individual, semi-structured survey questionnaires were used to collect the quantitative data on human behaviour in real condition of pesticides use. The participants included in this study were men or women who had lived in the locality for at least five years, applying pesticides in fields one year ago, and being at least 18 years old and having given their informed consent. The heads of households were required to answer questions about pesticide use in rice production. Surveys on the health risks associated with pesticide use can evaluate product management quality, producer attitudes and practices regarding product use, proper packaging disposal, and pesticide residue management. The survey asked farmers about the volume of pesticides they sold, the duration of their pesticide sales, their pesticide supply sources, the disposal of expired pesticides, their previous training on secure stock management, and their knowledge of the environmental risks associated with pesticide use. Additionally, the survey inquired about their awareness of the Sahelian Pesticide Committee (CSP), the regulatory body for pesticides. Additionally, the survey inquired about their awareness of the Sahelian Pesticide Committee (CSP), the regulatory body for pesticides.

2.3. Blood Samples Collections and Acetylcholinesterase Analysis

Blood samples were obtained by fingers stick sampling using a vaccinostyle. Farmers were randomly selected from each village group to evaluate the biological risks associated with pesticide usage in the study area. Plasma acetylcholinesterase (Erythrocyte Cholinesterase) levels were measured for each farmer. Sampling occurred in two rounds: the first round involved taking samples immediately after the surveys but before pesticides applications in fields. This initial sample was used as a reference value for monitoring the development of each individual's Erythrocyte Cholinesterase level. Then, farmers were requested to treat their fields based on the duration connected to the area of the land with pesticides. After the phytosanitary treatment, a second round of sampling was conducted. Both phases were carried out simultaneously by each farmer. After collection, the blood samples were directly analysed using the Test-mate Model 400 EQM® device reader. The erythrocyte acetylcholinesterase values were read according to the procedure described by Thiombiano *et al.* [17]. The results were available in less than one minute and communicated to the respondent before being sent to the laboratory. Data collection occurred before and after agrochemical treatments between 6 a.m. and 11 a.m. in both phases.

2.4. Data Analysis

The collected data were focused on agricultural practices in the rice-growing region, specifically the use of pesticides and the associated health and environmental risks. We analysed the data using Microsoft Excel and processed it according to the identified variables in the field. Means and percentages for each pesticide use practice studied were calculated using statistical parameters. This included the years of experience of farmers, types of pesticides used, CSP approval status, frequency of use, and active ingredient nature. The study analysed the causes of health consultations linked to poisoning, the protection methods used by farmers, the management of pesticide residues, and the elimination of empty packaging. The results were organised into histograms and frequency distribution tables. The inhibition of erythrocyte acetylcholinesterase activity before and after phytosanitary treatment was compared to biological analysis. Additionally, to describe the Erythrocyte Cholinesterase profile more accurately, we validated a method for analysing the assay results. Therefore, an average of two assays (before and after agrochemicals treatment) was measured, then, the results were categorised into activity classes for pseudocholinesterase based on their normal activity level. The following classes were established: Class A = [50% inhibition]; Class B = [30% inhibition]; Class C = [Normal class] U/L; Class D = [30% increase]; and Class E = [50% increase]. These classes are based on the fact that the World Health Organization uses 30% as the biological threshold for inhibition by organophosphates, which is the level up to which there is no risk of acute poisoning. Additionally, inhibition at approximately 50% indicates that the subject has a high chance of suffering from acute intoxication [18]-[21]. Class A and B are hazardous. Correlation (r or rho) was used to consider the effect of one variable on another because all the variables required for analysis are quantitative. A negative value of r causes a decrease in one variable when the other increases (negative correlation), while a positive value induces an increase in one variable when the other increases (positive correlation). The strength of correlation increases as the absolute value of rho approaches one. Pearson's correlation coefficient (rho) was utilised for variables that conform to a normal distribution, while Spearman's correlation coefficient (rho) was used otherwise. As a result, the relationships between age, years of experience in the use of pesticides and the results of the Erythrocyte Cholinesterase test were determined.

2.5. Ethical Considerations

Before collecting any field data, the study protocol underwent review and approval by an internal committee at the Centre Muraz under N°2022-15/MS/

SG/INSP/DG/CEI. This study used the human material and data were performed in accordance with the Declaration of Helsinki. In addition, regional director of health and public hygiene where this study was carried out, provided authorization of data collections under permission of the president of Bama Union of rice Farmers. The serum study sample was obtained from volunteer subjects who were provided with an explanation of the study's purpose and sampling conditions. The assay results were sent to all farmers. Data on the conduct of farmers and distributors was collected by investigation teams with the assistance of a locally recruited guide. Before conducting fingerstick sampling using a vaccinostyle for in situ biological testing with the Test-mate Model 400 EQM® portable plasma cholinesterase reader, all farmers provided their consent.

3. Results

3.1. Socio-Demographic Characteristics of Study Participants

The analysis revealed that rice cultivation in Bama is mainly done by men, with 92.3% of farmers being male and only 7.7% being female. The average age of farmers was 45 years, with a range of 20 to 64 years. Among all respondents, 10.9% were under 40 years old, 6.6% were between 40 and 50 years old, and 82.5% were over 50 years old (**Table 1**). Individuals over 40 years old were responsible for almost 90% of rice cultivation. Additionally, a majority of participants had a low level of education, with 48.3% attending primary school, 10.9% attending secondary school, and 40.8% receiving no formal education. Only 15.4% of surveyed farmers received agricultural training. The survey conducted in the study area showed that 16.5% of farmers had less than 10 years of experience using pesticides. Additionally, 39.6% of farmers had experience between 10 and 20 years, while over 40% had more than 20 years of experience (**Table 1**). About 60% of farmers had an average experience of less than 20 years in pesticide use.

3.2. Use of Pesticides by Farmers

Surveys of rice farmers showed that they use synthetic herbicides to weed their crops. The survey identified 11 pesticides, including herbicides and insecticides, by their trade names. Five herbicides were intended for rice cultivation, two for cotton cultivation, and two for growing cereal and potato fields (known as "total herbicides"). Products such as Gramoxone, which is based on glyphosate, and Lambda, which is based on Lambdacyhaothrin, were present but not approved by the Sahelian Pesticides Committee (CSP) (**Table 2**).

Glyphader (26.7%), MegaSuper (24.4%), Lambda (13.3%), and Ladaba (12.2%) are the most commonly used herbicides among farmers. However, these herbicides also result in the highest dumping of active materials in the rice-growing areas of Bama and its surroundings, specifically glyphosate and bispyribac-sodium. Among rice farmers in the Bama plain, the most commonly used insecticides are Lambda (lamdacyhalothirne), Emacot (Emamectin benzoate), and Emapyr (Emamectin henzoate + Pyriproxyphene). However, it is important to note that

18.18% of pesticides used in rice-growing lowlands are not approved and are prohibited, such as Paraquat. The presence of unregistered products in the market poses significant health hazards to the population.

Table 1. Socio-professional characteristics of rice farmers.

Parameters	Category	Total number (n = 91)	Proportion (%)
Gender	Male	84	92.3
	Female	7	7.7
Ages (years)	<40	10	10.9
	40 - 50	6	6.6
	>50	75	82.5
Level of education	Primary	44	48.3
	Secondary	10	10.9
	None	37	40.8
Agricultural training received	Yes	14	15.4
	No	77	84.6
Years of experience in pesticide use	<10	15	6.5
	10 - 20	36	39.6
	>20	40	43.9

Table 2. Types of pesticides used by farmers.

Trade name of company Product	Active ingredient	Class of pesticides	Targeting use	Frequency of use (%)	Approved by the Sahel Pesticides Committee
MegaSuper	Bispyribac-sodium	Herbicide	rice	24.4	Yes
Glyphader	Glyphosate	Herbicide	Cotton	26.7	Yes
Ladaba	Glyphosate	Herbicide	Cotton	12.2	Yes
Gramoxone	Paraquat	Herbicide	Cereal, cotton, potatoes	10	No
Ce Propre	Bispyribac-sodium	Herbicide	Rice	5.6	Yes
Herbextra	2'+D Sel de dimelhylamine	Herbicid	Rice	1.1	Yes
Lambda	Lambdacyhalothrine	Insecticide	Cereal, cotton, potatoes	13.3	No
Samory	Bensulfuron-méthyl	Herbicide	Rice	1.1	Yes
Roundup	Glyphosate	Herbicide	Rice	2.2	Yes
Emacot	Emamectine benzoate	Insecticide	Cotton	1.1	Yes
Emapyr	Emamectine henzoate + Pyriproxyphene	Insecticide	Cotton	2.2	Yes

3.3. Health Risks Associated with the Use of Pesticides

3.3.1. Impact of Pesticide Use on Health

According to the survey results, 48.3% of the respondents experienced accidents while handling or treating rice fields with pesticides. All respondents who encountered an accident while using pesticides reported spilling the product of themselves. In all cases, the initial response was to cleanse the affected area with soap and water. Out of the individuals who had an accident while using pesticides, 56.4% reported experiencing health effects that they associated with pesticide use. These health effects include respiratory (25%), skin (18.7%), gastrointestinal (6.4%), and eye (6.2%) disorders (**Table 3**).

Table 3. Types of pesticide-related illness reported by rice farmers.

Accidents related to pesticides use	Fréquence (%)
Status of accidents	
Oui	48.3
Non	51.7
Type of accident	
spilling the pesticide on itself	100
Immediate action taken after accident	
washing the body part with soap and water	100
Reason for requesting a consultation	
Acute gastric disorders	6.4
Skin disorders	18.7
Respiratory disorders	25
Eye disorders	6.2
Other	43.7

3.3.2. Risks Associated with Inadequate Protection When Handling Pesticides

The study revealed that a significant number of farmers, 27%, do not use adequate protective equipment, such as masks, gloves, and clothing, during broth preparation or processing. These farmers often wear second-hand clothing, including torn shirts and trousers. When it comes to pesticide preparation and applications, only 73% of farmers protect a part of their body, with 23% using dust masks and boots as a means of protection (**Figure 2**). Shockingly, only 1% of respondents were equipped with the necessary suit for using and managing pesticides.

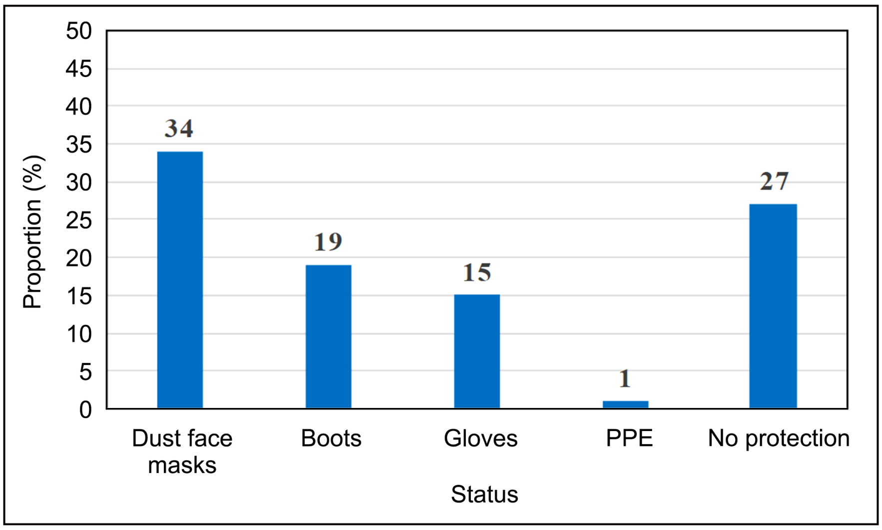

Figure 2. Protective measures used by farmers "PPE" or "Personal Protection Equipment".

3.4. Environmental Pollution Risks Associated with Pesticide Use

3.4.1. Pesticide Residue Management Methods

Out of the surveyed farmers, 43.9% reported using their entire pesticide mixture for treatment. Observations indicate that 9.9% of cases involve reusing leftover pesticides, and 34.1% of farmers store these leftovers at home for future use. For 12.1% of farmers, the remaining pesticide mixture is either buried or dumped into the environment (Figure 3).

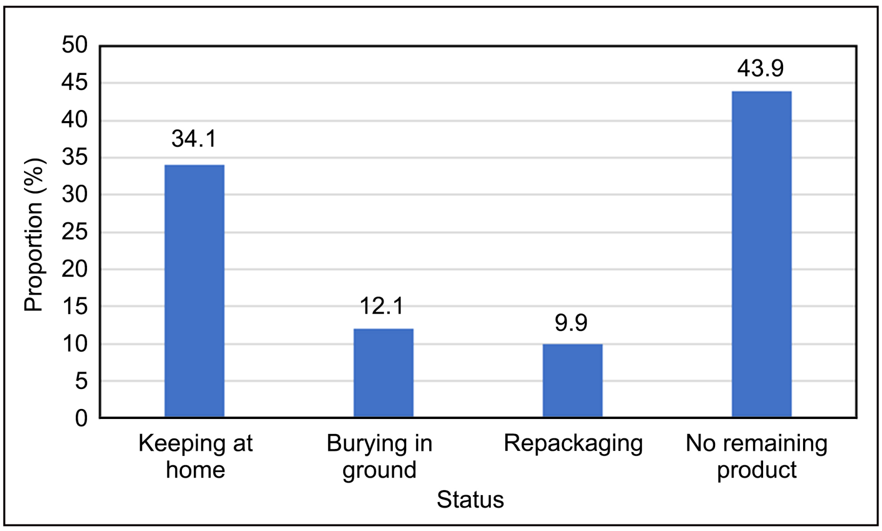

Figure 3. Management of pesticide residues by farmers.

3.4.2. Inadequate Methods for Dealing with Empty Packaging after Having Used

The findings of the survey revealed different methods of disposing of pesticide packaging and containers after use. Nearly half (49.4%) of the farmers abandon the packaging in or near the fields. Incineration is the method used by 13.2% of the farmers to dispose of packaging and empty containers. Empty packaging is buried in a dug hole near the field by 35.2% of respondents. Only 2.2% of farmers store empty packaging at home (Figure 4).

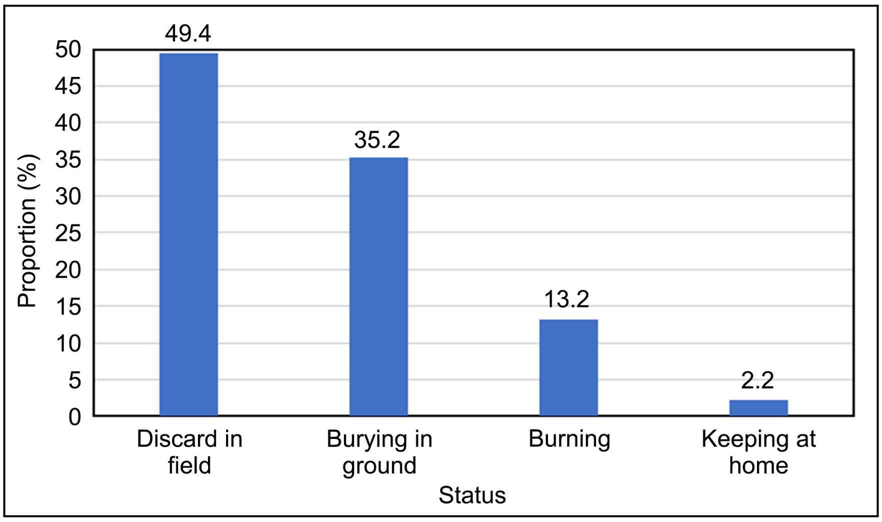

Figure 4. Main methods of disposing of empty pesticide packaging.

3.4.3. Risk of Contamination of Water Points by Flushing Treatment Equipment

The survey showed that most water points were located within 10 metres of rice fields (62.7%), another 18.7% between 10 and 20 metres, and only 5.5% more than 100 metres (see "Table 4"). In addition, all participants reported washing their equipment after phytosanitary treatment, with rinsing taking place exclusively at water points. It is worth noting that the river (Kou Valley) was the only source of water for all respondents.

Table 4. Characteristics of watercourses used for washing agrochemical treatment equipment.

Watercourse near rice fields	Proportion (%)
Yes	100
Type of watercourse	
River (Kou Valley)	100
distance from watercourses and rice fields	
<10	63.7
10-50	18.7
51-100	12.1
>100	5.5
Pesticide treatment equipment rinse water points	
River (Kou Valley)	100

3.5. Performance of the Portable Device (Test-Mate Model 400 EQM®) for Measurement of Biomarkers of Pesticide-Related Poisoning in Rice Farmers

A total of 32 male farmers were recruited for the study. Glyphosate (Glyphader and Ladaba) was the most common organophosphate pesticide used for spraying (38.9%). Farmers sprayed an area ranging from 0.25 ha (12 farmers) to more than 1 ha (1 farmer), with 0.5 has been the most common (17 farmers). In addition, the time required to treat rice fields varied from 10 to 78 minutes (1 h 18 min) depending on the area, with an average of 30 minutes. Note that metrics and units are strictly adhered to. The volume of the insecticide preparation depends on the size of the field and ranges from 10 to 45 litres (Table 5). The mean erythrocyte ChE activity was 3128 IU/L, with a minimum of 1910 IU/L and a maximum of 4565 IU/L (Table 5). In addition, the results showed no individuals in category A and six farmers; representing 18.75%, in Category B (Figure 5), both of which are considered hazardous. Therefore, these people in category B are at risk of acute poisoning associated with glyphosate use. In addition, the majority of farmers, 26 in total (81.25%), fell into group C or the normal classification, where the erythrocyte cholinesterase inhibition rate ranged from 0 to 30% (Figure 5). The study analysed the relationship between age and years of pesticide use by farmers and erythrocyte cholinesterase inhibition. The analysis revealed a significant correlation between farmer age and erythrocyte cholinesterase inhibition ($P < 0.043$, Spearman (rho): 0.36 with CI95: 0.00 - 0.64). However, this study did not show an association between the number of years of experience in pesticide use and erythrocyte cholinesterase inhibition in farmers ($P = 0.394$, Spearman (rho): 0.16 with CI95: 0.0 - 0.49).

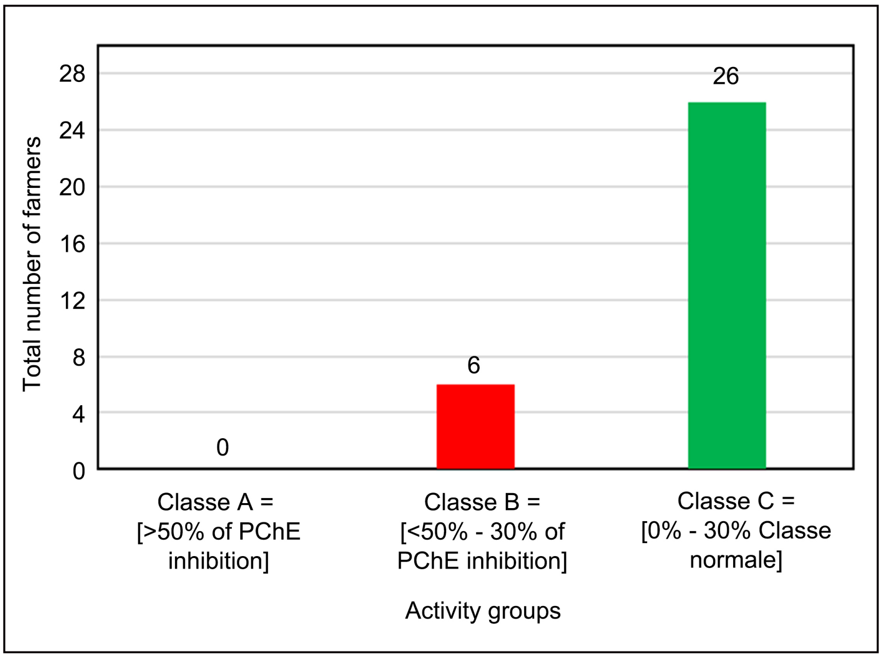

Figure 5. Distribution of rice field farmers by Erythrocytes ChE activity class.

Table 5. Rice fields treatment conditions and average level of PChE among rice farmers.

Treatment conditions in rice fields by farmers			
	Mean	Minimum	Maximum
Treated surface area (hectare)	0.625	0.25	1
Time of spraying (mn)	33	10	78
Sprayed volume (Litre)	22	10	45
Biomarkers of AChE intoxication (N = 32)			
Mean Erythrocytes ChE (IU/L)	3128	1910	4565

4. Discussion

This study describes the current state of agriculture in the rice-growing region of Bama. The area has been cultivated since the 1970s using effective cultural practices that follow well-organized plans. Today, in the pursuit of food self-sufficiency, farmers are growing additional crops such as maize, sorghum, cotton, and sesame in addition to rice. The increase in crop yields forces farmers to use various pesticides (approved or not) during production. While this is beneficial to farmers, it can have negative impacts on both humans and the environment. In addition, this study presents the results of testing the ability of a handheld device to detect activity in whole blood and plasma samples. The evaluation showed impressive levels of accuracy, specificity and precision [17]. In addition to cumbersome laboratory equipment that is difficult to transport to the field, blood samples can denature during transport, making analysis difficult. In this study, a portable spectrophotometer (Test-mate Model 400 EQM®) was used in the rice-growing plain of Bama to obtain reliable real-time cholinesterase levels in rice farmers. Providing farmers with on-the-spot cholinesterase dosage results, enabling them to make informed decisions about their health, is another advantage of using this portable device.

The traditional status of the land in the area, where the land belongs to the oldest member of the families, has also contributed to the aging of the population. The presence of older people on plots in an agricultural context that relies heavily on pesticides is worrying, given that the functional capacity of certain vital organs declines with age [22]. Furthermore, our analysis revealed a worrying association between farmers' age and inhibition of erythrocyte cholinesterase activity. This finding is troubling because the majority of farmers in the region have an average of 20 years of experience using or handling pesticides. In addition, the limited participation of women can be attributed to the traditional land status that favours men [23]. A plot allocated to a woman may be given to another household member or close relative. In addition, the study found that the majority of rice production in the lowlands was carried out by an illiterate population (40.8%) with no agricultural training. Only 48.2% of the population surveyed had received primary education. In fact, the inability to read and the lack of education have hindered the adherence to good practices in the use of pesticides, especially the wearing of appropriate personal protective equipment and the proper preparation and use of pesticides. In addition, the low level of education of farmers contributes to the disregard of instructions, resulting in the medium to long-term risks of poisoning in the cotton-growing regions of Burkina Faso [24]. This study shows that the main active ingredients of the herbicides used were mostly glyphosate. Glyphosate, a substance that is toxic to both humans and the environment, is present at a concentration of 26.7%. In addition, 18.18% of the pesticides used to treat plots are not approved by the CSP. The excessive use of unauthorized pesticides can be attributed to poor practices, which are the result of lack of education, ignorance and poverty. The population resorts to using cheap smuggled products. In addition, the majority of farmers (63%) only protected certain parts of their bodies when preparing and applying pesticides, resulting in inadequate protection during treatments. As a result, farmers suffered direct poisoning from inhalation, skin or eye contact with the pesticides. The study identified seven individuals with 30% - 50% inhibition of erythrocyte cholinesterase activity. None of the participants had a reduction in activity of at least 50% (class A) compared to normal (class C). The presence of classes A and B could be attributed to genetic factors (specifically the presence of abnormal hereditary variants) [25] as well as acquired causes. Cases of acute or chronic hepatitis [26] were observed in this study. There was a negative and non-significant correlation between years of exposure and depression of AChE activity in farmers, which is expected due to normal erythrocyte turnover. However, the age of the farmers had a strong influence on the depression of AChE activity. This finding may be attributed to the older age of the study participants and the prevalence of chronic diseases, which could further decrease the activity of erythrocyte cholinesterase in the elderly. In fact, certain pathological conditions such as severe kidney damage, collagenases, and acute infections [27]; impregnation with organophosphate compounds [27]; and certain medications used to treat myasthenia gravis, intestinal atony, Alzheimer's disease, oral contraceptives, and other conditions [26] could result in a reduction of erythrocyte cholinesterase activity. In addition, anaemia, malnutrition, and neuromuscular damage, including neuromuscular syndrome and dermatomyositis, may also be responsible for this reduction [28]. A study that examines the clinical aspects of rice farmers in the Bama rice-growing plain is crucial. In addition, the characteristics of the study population may be related to the observed increase in activity levels. In particular, an increase in plasma cholinesterase levels occurs in more than 90% of acute myocardial infarction and nephrotic syndrome cases [28].

5. Conclusion

The survey of the health risks associated with the misuse of pesticides in the rice-growing lowlands of Bama in western Burkina Faso showed that farmers suffer from poisoning. These poisonings are linked to the negligence and unsuitability of personal protective equipment used and to the storage of pesticide residues at home. The socio-demographic context is also marked by the low level of education of those involved, which prevents them from following the instructions on pesticide packaging. The prevalence of pesticide poisoning in these conditions is underestimated because the health centres only recorded the critical cases that were treated first.

The study suggests an extensive awareness-raising campaign for stakeholders (households, traders, etc.) in pesticide management in general and rice growers in particular. Awareness-raising sessions, particularly on market days, and the work of community-based health workers in the villages should be stepped up to ensure that information on the safe management of agricultural pesticides is widely disseminated. To better assess the prevalence of pesticide poisoning, health services in areas of high pesticide use will also need to be made aware of the need for detailed information on all pesticide poisoning to be recorded in health registers. In addition, regular biomonitoring of acetylcholinesterase (AChE) activity in rice farmers is needed to prevent unintentional and undetected acute and/or chronic insecticide poisoning. This should be institutionalised to ensure effective prevention among farmers. The study confirms that rice farmers are professionally exposed and therefore require consistent monitoring. Therefore, it is necessary to strengthen awareness sessions, especially on market days, as well as the role of community-based health workers in villages to promote widespread dissemination of information on safe use of agricultural pesticides.

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Data Availability Statement

The data generated and analysed during the current study are all published in the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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