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Analysis of pesticide use in farming practices in Northern Cameroon

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This study aims to contribute to a reduction in the health and environmental risks associated with the use of chemical pesticides. Three hundred farmers, stockbreeders, and agro-pastoralists were selected and surveyed in a reasoned manner in the Departments of Benoue, Faro, Mayo Rey, and Mayo Louti. Twenty-four pesticides were identified as the most widely used, along with herbicides. Some turn out to be counterfeit (Feodal Goal). The frequency with which they are used varies from one producer to another. Some use them once per crop production cycle (15%), others use them two to four times per production cycle (72%), and some even use them more than four times per crop production cycle (13%). The majority of respondents stated that they had observed inappropriate behavior in the animals after their return from grazing (lung disease, diarrhea, mouth and paw sores, runny nose, belly bloating, heart disease, and paralysis). The correlation between the state of health of the animals and the pesticides used shows a positive relationship between these variables. It is important that emphasis be placed on the training and ongoing awareness-raising of retailers and producers on good practices in the use of pesticides.

Key words: Chemical pesticides, health and environmental risks, producers, grazing.

INTRODUCTION

The use of plant protection products in agriculture can be seen as a necessary evil to ensure that farmers can effectively protect their crops and achieve the productivity they desire. Over the last 50 years, pesticides (insecticides, fungicides, herbicides) have enabled farmers to increase their agricultural production and land productivity. At the same time, the negative externalities arising from the use of these inputs and their toxicity have gradually led to environmental problems affecting ecosystems and human health (Olina Bassala et al., 2015). These externalities include damage to farmland, livestock, and wildlife (Wilson and Tisdell, 2001). In addition, the more acute toxicity problems observed in developed countries that use more of these chemicals, notably human and animal morbidity and mortality due to exposure to these pesticides are already beginning to occur in developing countries, particularly in Cameroon (Inserm, 2021).

Due to the harmful effects of pests and weeds on yields, the amount of chemical pesticides used is increasing every year. In addition, several studies have

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shown the importance of the use of chemical pesticides in agriculture. According to Toé (2003), phytosanitary treatments are certainly a factor in agricultural development. They make it possible to control crop pests, particularly those affecting cash crops, sugar cane, and market gardening (Toé, 2005). Furthermore, the use of pesticides has become one of many attractive alternatives for avoiding bottlenecks in the cropping calendar and facilitating maintenance work (Sory, 2011). These phytosanitary products have become increasingly important in agriculture in all countries, including Cameroon. Effective on certain grasses that are harmful to cultivated plants, they are considered harmful to human populations, and their use on certain crops is now being questioned because of the possible toxicity of the products derived from their decomposition and the emergence of resistance in certain weeds (Le Bars et al., 2020). In Cameroon, 81% of farmers do not comply with the recommended application rates (Temple et al., 2024). This is why in Kenya, for example, initiatives such as the introduction of biopesticides have been put in place to offer safer alternatives to conventional chemical pesticides (Netia and Hereward, 2024). However, although heat has a positive effect on the degradation of active ingredients, various pesticides banned in Europe are still used in agriculture in many sub-Saharan African countries (Brosché, 2024; Heinrich, 2023). It is important to note, however, that the abusive and uncontrolled use of these products is not without effects on human and animal health and the environment (Maitre et al., 2022).

According to Devez (2004), the pesticides used can be carried to very distant resources in biotopes through atmospheric movements. This is one of the reasons why, for example, the proximity of certain agricultural areas to grazing areas now poses a problem of fodder contamination. This is due to the land constraint, which makes it more difficult for people to find land for farming, leading to the excessive use of pesticides. All in all, to help reduce these bottlenecks further, the use of biological pesticides in agriculture is a very effective alternative. Unfortunately, however, their use is still very limited on the African continent and in Cameroon, in particular (Soulé Adam, 2024; Korangi Alleluya, 2021). These organic products help minimize the damage caused by chemical pesticides while making an effective contribution to combating the pests and diseases that affect crops. Given the scale of the risks associated with the use of pesticides, this study aims to help limit them. Overall, by assessing the effects of pesticide use on farmers, the study aims to help reduce the health and environmental risks associated with their use.

MATERIALS AND METHODS

Study area

This study was carried out in the Northern Region, in the five Departments that make up this region, namely: Bénoué, Faro, Mayo Rey, and Mayo Louti. More specifically, it was conducted in the following Boroughs: Lagdo (locality of Bamé); Ngong (locality of Ndjola); Pitoa (locality of Be); Poli (locality of Pintchoumba); Mayo Oulo (locality of Kouboutou); Guider (locality of Gatouguel); Figuil (locality of Bafouni); Bibemi (locality of Houla Djalingo); Rey Bouba (locality of Tolloré); and Garoua 3 (locality of Israël). Figure 1 opposite shows the location map of the localities targeted for this study.

Equipment

The equipment used for this study included survey forms that had been set up and digitized in the ODK Collect mobile application, as well as digital tablets equipped with this mobile application for administering the questionnaire. Data analysis was performed using Excel (version 2013) and R software (version 4.4.2).

Criteria for choosing study sites

Several criteria guided the selection of study sites. In the localities studied, these sites have large agricultural areas and extensive grazing lands, with livestock keepers who own large herds. These localities are recognized as major agro-pastoral basins in the Northern Cameroon Region.

Field survey

The questionnaire method was used. First, a pre-survey was conducted among a dozen farmers in the locality of Lagdo (Bamé) to test the questionnaire and correct any imperfections. For the actual survey phase, non-probabilistic, purposive sampling was chosen. In this study, 300 farmers, stockbreeders, and agro-pastoralists were selected purposively in the Departments and Boroughs listed above (30 people per Borough). The selection was made between farmers with cultivated land ready for grazing, stockbreeders with large herds, and agro-pastoralists with both of these resources. To do this, semi-structured interviews and focus groups, where appropriate, were carried out in the various localities with the agreement of the administrative authorities present. The choice of respondents was carefully considered, as agro-pastoralists, livestock breeders, and farmers who use grazing areas in their localities and also cultivate around these areas were selected. Finally, the data collected was downloaded onto the Kobo Humanitarian platform and exported using the Excel spreadsheet extension, processed, and analyzed in R and Excel.

RESULTS

Pesticides used in the study area

For this study, during the previous survey phase, 24 pesticides used by farmers in the field were identified. The survey was based on a series of questions asked to farmers about the pesticides they use. Figure 2 opposite shows the pesticides used in the study localities, classified into three families: herbicides, insecticides, and fungicides, each with a percentage of use. In the herbicide family, Atrazine is the most widely used herbicide in all the study sites (21.3%), followed by Roundup (20.6%), Gramoxone (19.4%), Duiron (10.6%), Herbimaïs (5.9%), Delemine (5.8%), and Supermachette (3.8%). At the bottom of the ranking are Glyphader,

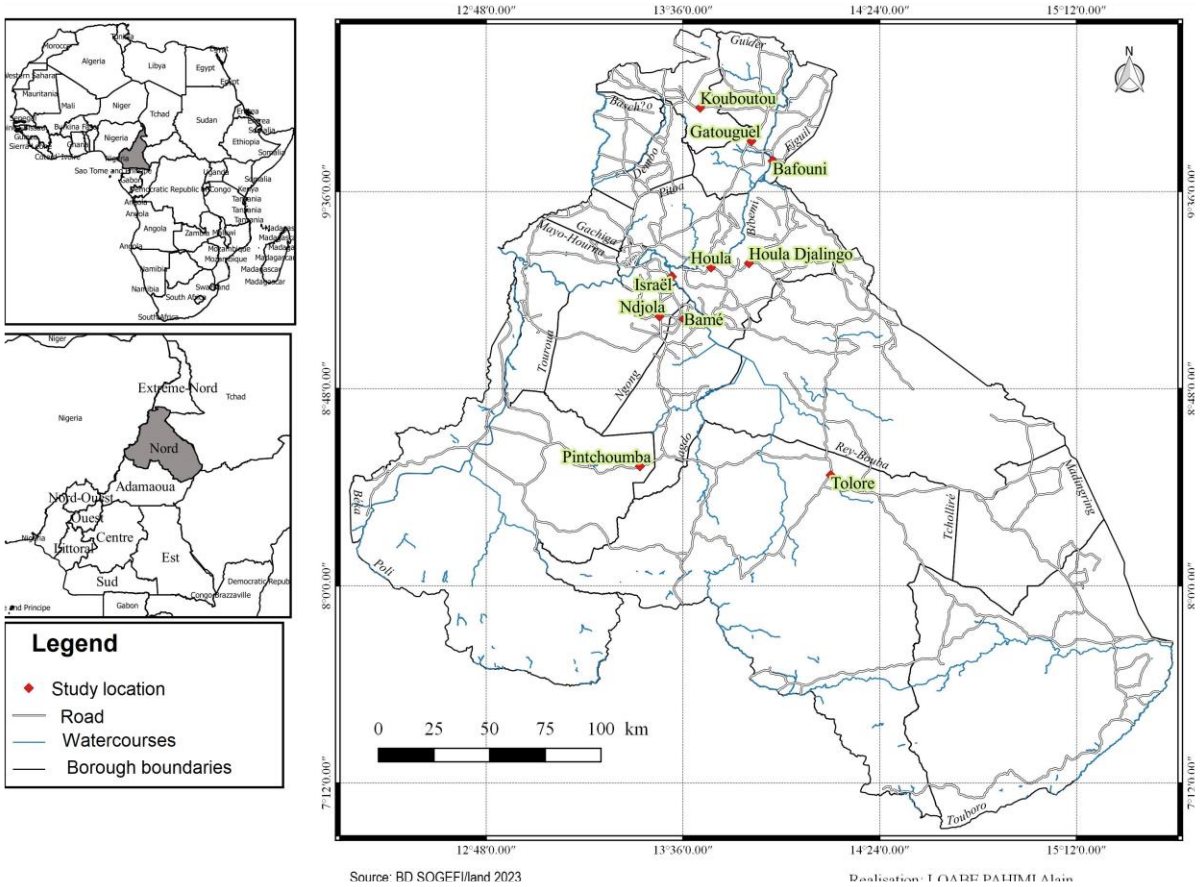

Figure 1. Location map of the study area.

Nicomaïs, Atralm, Palace, Codagol, Kalach, Kerakol, and Féodal Goal, each with a percentage of 0.3%. At the bottom of the ranking are Miyidima (1.2%), Herbiriz (1.1%), Herbistar (0.6%), and Rubis (0.6%). Pesticides belonging to the insecticide family include: Insector (0.5%), Benji (2%), Optimal (3%), and Imperator (0.3%). Finally, as a pesticide belonging to the fungicide family, only one was found: Marshall (1.1%).

The pesticides identified were grouped in the study boroughs by class of active ingredient. The results obtained are shown in Table 1. The results in Table 1 show that the study localities have a diversity of active ingredients, demonstrating the complexity of the agricultural environment in the North Cameroon Region. In addition, the frequency of use of the pesticides listed and classified by active ingredient varies from one farmer to another. Some use them just once per crop production cycle (15% of the sample surveyed), others use them between 2 and 4 times per production cycle (72% of the sample surveyed), and some even use them more than 4 times per crop production cycle (13% of the sample surveyed). Additionally, the doses at which farmers apply these pesticides in the field also vary, but it is noted that the majority of respondents respect the manufacturer's application doses (69% of respondents), which are generally, for example, a 500 g sachet for 2,500 m^2 of farmland or ½ liter of product for 2,500 m^2 of farmland for a herbicide such as Roundup. On the other hand, a minority (31% of respondents) refrain from the proper management and use of pesticides.

How farmers use pesticides

This method of use varies from one farmer to another. Some prefer to combine several pesticides with the same active ingredient, such as Roundup with Herbistar (21% of respondents), before use. Other farmers combine several pesticides, such as Gramoxone, Atrazine, and Roundup, before applying them in the field (35% of respondents). Still others prefer to apply different pesticides at different stages of the agricultural season, for example: Gramoxone before sowing, Roundup + Gramoxone just after sowing, and Atrazine after emergence (55% of respondents). The pesticide is generally applied very early in the morning when there is a little dew or in the evening by the majority of respondents (90% of respondents). However, it should be

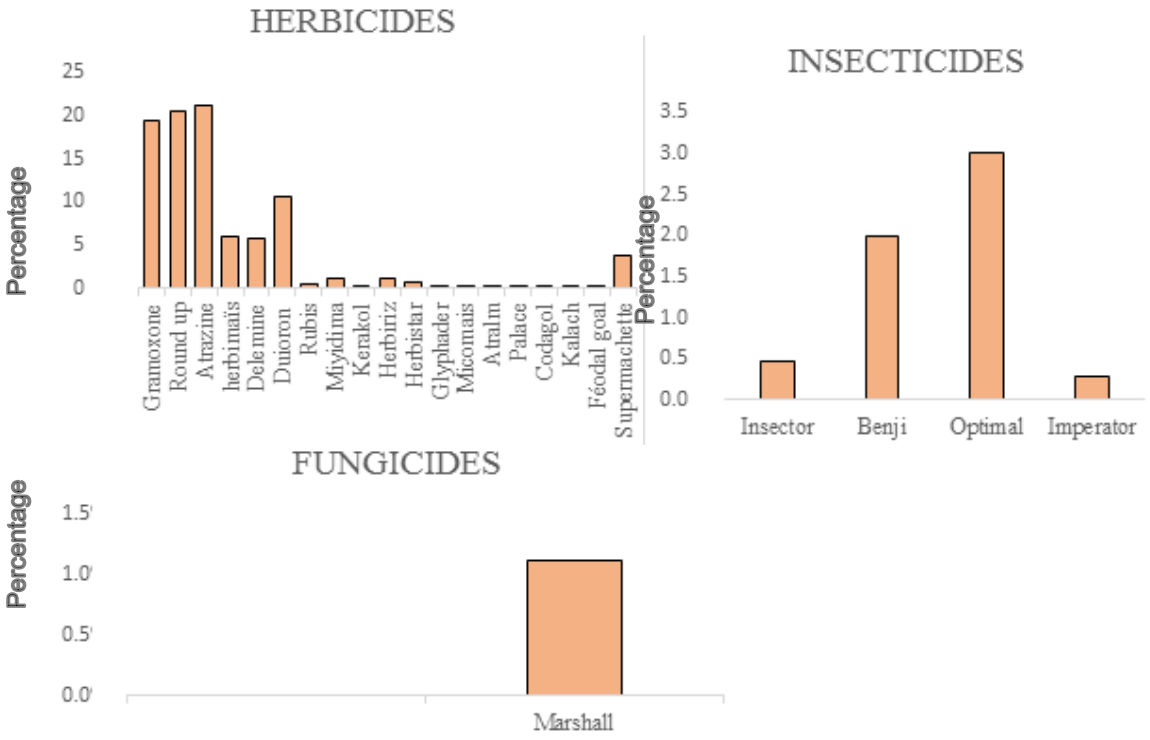

Figure 2. Pesticides used in the study localities.

noted that farmers also apply them after rainfall.

Impacts and causes of pesticide contamination of fodder and grazing animals

The perception of the impacts of pesticide use in general by the farmers surveyed is quite clear, and for some, it is even self-evident. The majority of farmers surveyed (100%) had observed a change in the environment of grazing areas close to agricultural fields. In addition, 72% of respondents said they had observed the appearance of undesirable weeds, while 28% said they had observed nothing at all. Among those who said they had observed the appearance of undesirable weeds, 54% said that it had been since farmers started using herbicides in the field. However, 18% of these respondents had difficulty estimating the precise moment when undesirable weeds appeared in the field. On the other hand, 28% of these respondents said they had observed the appearance of weeds very recently. Table 2 shows the undesirable weed species identified during the survey in the study areas.

Figure 3 presents farmers' perceptions of the elements of the environment affected by farming practices and having an impact on grazing areas. The graph shows that 25% of respondents think that the elements of the environment most affected are vegetation and the wooded landscape; 20% of respondents thought that it was the vegetation and the soil; 19% of respondents thought that it was the soil, vegetation, and the wooded landscape; 14% of respondents thought that it was the vegetation, the wooded landscape, and the existing water points; 8% of respondents thought that it was the soil, vegetation, and the wooded landscape; 5% of those surveyed referred to the soil, vegetation, wooded landscape, and existing water points; 4% saw more vegetation, wooded landscape, and animal biodiversity; 2% saw the soil, vegetation, wooded landscape, and animal biodiversity, and finally, 2% of those surveyed thought only of vegetation.

Figure 4 presents the causes of fodder contamination in the grazing areas used by the animals of the farmers surveyed. The figure shows that 35% of respondents thought that overdosing of pesticides in the field was the main cause of fodder contamination in grazing areas; for them, the second most common causes were: the volatile nature of the pesticide used in the field (20%) and the poor use of crop treatment equipment such as sprayers (20%); the fragility of the soil (5%) and the permeability of certain soils (1%) came last.

When farmers were asked about the cause of fodder contamination in relation to the proximity of their agricultural fields to grazing areas, 98% said that the proximity of their fields to grazing areas was a source of pesticide contamination. On the other hand, 2% did not feel this way; for them, there was no link between grazing areas and agricultural fields. Among those who

Table 1. Classification of pesticides identified by class of active ingredient.

No.	Generic names	Active ingredient	Region concerned
01	Atrazine	Atrazine	Nord Cameroon
02	Round up	Glyphosate	Nord Cameroon
03	Gramoxone	Paraquat	Nord Cameroon
04	Duioron	Duioron	Nord Cameroon
05	Herbimaïs	Atrazine + Nicosulfuron	Nord Cameroon
06	Supermachette	Glyphosate	Nord Cameroon
07	Delemine	Inconnu	Nord Cameroon
08	Miyidima	Haloxyfop-R-Methyl	Nord Cameroon
09	Herbiriz	Bensulfuron	Nord Cameroon
10	Marshall	Carbosulfan	Nord Cameroon
11	Rubis	Bispyribac	Nord Cameroon
12	Herbistar	Glyphosate	Nord Cameroon
13	Insector	Carbosulfan	Nord Cameroon
14	Glyphader	Glyphosate	Nord Cameroon
15	Nicomaïs	Nicosulfuron	Nord Cameroon
16	Atralm	Atrazine	Nord Cameroon
17	Palace	Pyrithiobac-sodium	Nord Cameroon
18	Codagol	Pro-etryne + Metolachlore	Nord Cameroon
19	Imperator	Carbosulfan	Nord Cameroon
20	Kerakol	Inconnu	Nord Cameroon
21	Féodal goal	Inconnu	Nord Cameroon
22	Kalach	Glyphosate	Nord Cameroon
23	Optimal	Acetamipride	Nord Cameroon
24	Benji	Acetamipride	Nord Cameroon

Table 2. Undesirable weed species identified.

No	Species
01	*Thelepogan elegans*
02	*Pennisetum pedicellatum*
03	*Rottboellia cochinchinensis*
04	*Cyperus rotundus*
05	*Commelina forskalaei*
06	*Cassia obtusifolia*
07	*Lannea humilis*

recognized a link between these two areas, 35% thought that this was due to runoff of the product (pesticide) applied in the field; 50% thought more of volatilization of the product during application in the field, and 15% thought more of infiltration of the product after application.

Generally speaking, the majority of respondents stated that they had observed inappropriate animal behavior after their return from grazing, particularly after the farmers had applied pesticides in the field (98%). Figure 5, opposite, shows the various health conditions identified by farmers as being linked to the use of pesticides, particularly those containing glyphosate as an active ingredient. Lung disease topped the list at 54%, followed by diarrhea (18%), mouth and leg sores (10%), runny nose (9%), belly bloating (4%), heart disease (2%), and paralysis (2%).

Correlation between the state of health of the animals and the pesticides used

Table 3 shows the correlation between the state of health of the animals after their return from grazing and the pesticides most commonly used by the farmers. During the ANOVA test, a Pr (>P) below the significance threshold of 0.05 was obtained. The probability of obtaining a P-value greater than 770.8 by chance is low. In this case, the null hypothesis is rejected.

DISCUSSION

Out of the 24 pesticides identified in all the localities surveyed, herbicides were found to be the most common, with the highest percentage. Four herbicides stand out: Atrazine, Roundup, Gramoxone, and Duiron. This predominance of herbicides over other types of pesticides (insecticides such as Optimal or Benji, and the fungicide

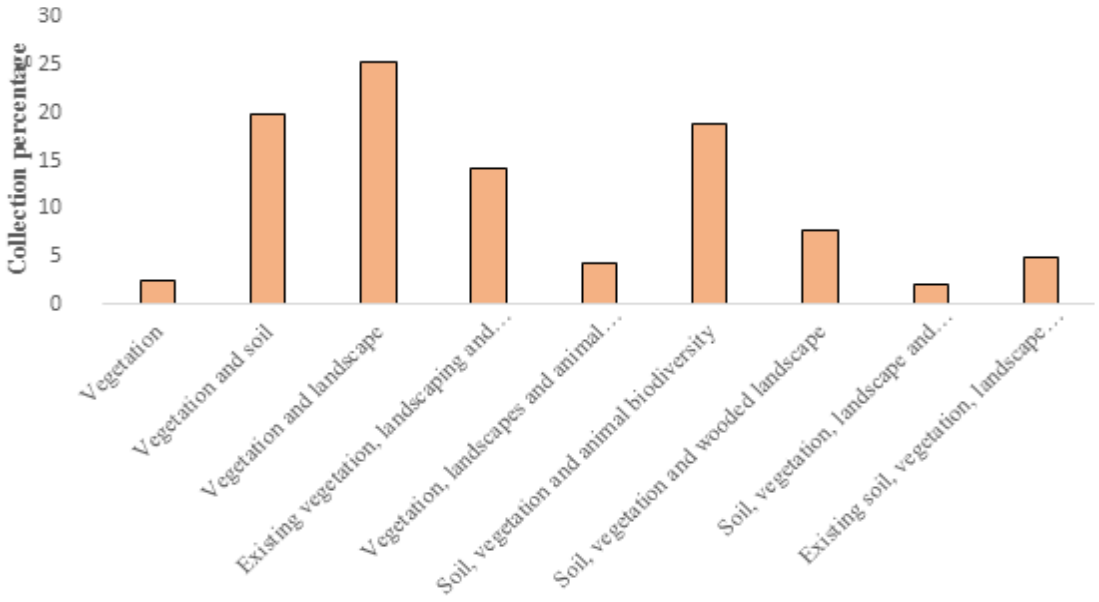

Figure 3. Elements of the environment affected in grazing areas close to agricultural fields

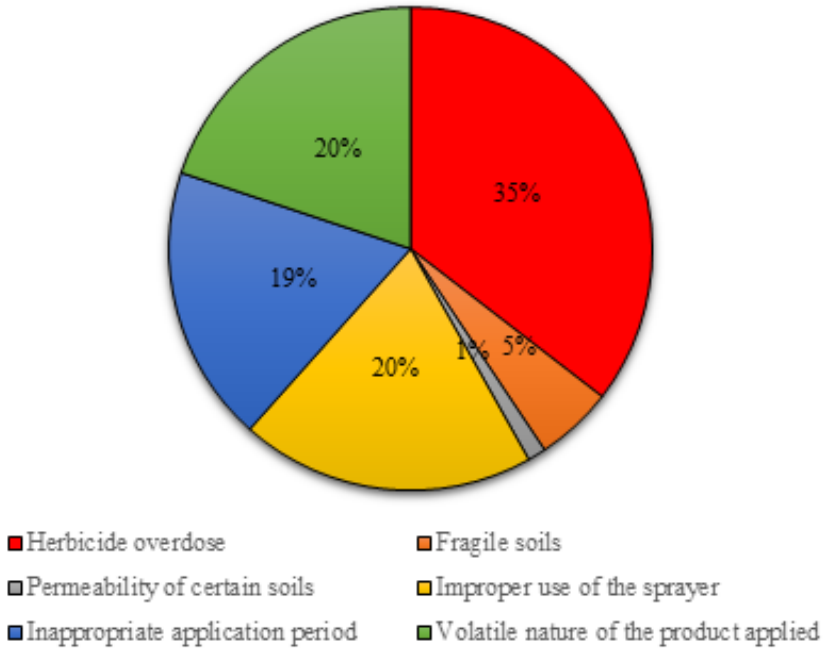

Figure 4. Cause of fodder contamination in grazing areas.

Marshall) can be explained by the fact that, at the start of the agricultural season, farmers prefer to use pesticides that quickly eliminate undesirable weeds and then opt for other types of pesticides, such as Optimal for insecticide treatment or Marshall for fungicide treatment. This result corroborates the work of Ntow et al. (2006) in Ghana, who identified pesticides with a higher number of herbicides than those found in this study.

Furthermore, among these pesticides, one whose generic name is Feodal Goal turns out to be a counterfeit herbicide from neighboring countries. In fact, it does not appear on the list of phytosanitary products approved by the Ministry of Agriculture and Rural Development (MINADER), the ministry responsible for approving

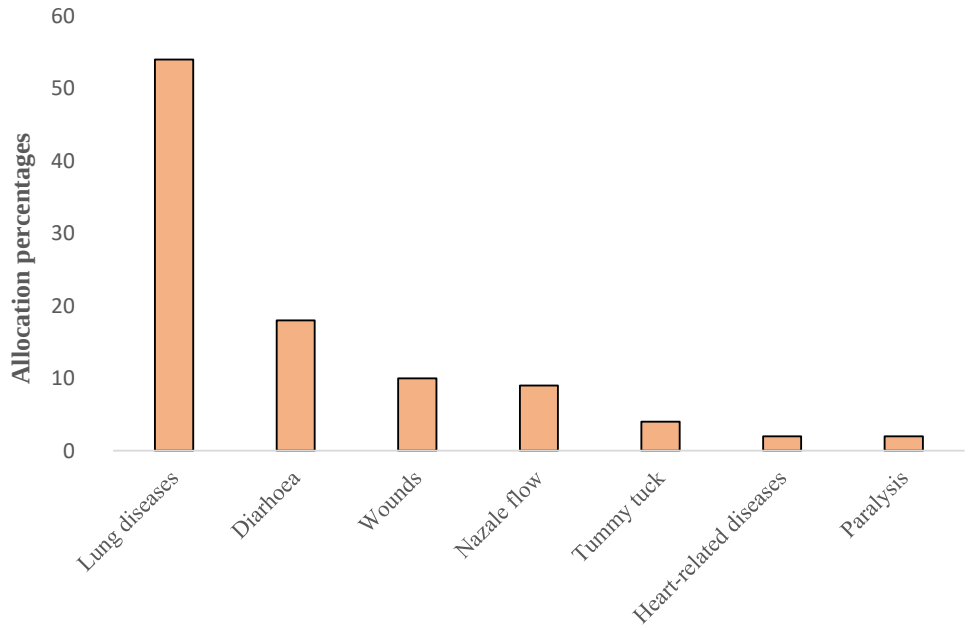

Figure 5. Health conditions reported by farmers after their animals returned from grazing.

Table 3. Correlation between animal health and pesticides used.

Variable	Df	Sum Sq	Mean Sq	P value	Pr (>P)	Significance code
Pesticides used	6	637.8	106.29	770.8	$<2e^{-16}$	***
Residuals	292	40.3	0.14			

Sig. codes: 0 '***'; 0.001'**'; 0.01 '*'; 0. 05 '.'; 0.1 ' ' ; 1.

pesticides in Cameroon. Other counterfeit pesticides from neighboring countries are also found in the localities surveyed and in border areas. These include herbicides with the same generic name as Roundup, Supermachette, and many others. This result somewhat corroborates that of Diop (2013), who discovered in Senegal that several pesticides used in market gardening come from counterfeit circuits that repackage and relabel products in 250 ml bottles or 25 to 100 g sachets. This finding also supports Tourneux (2010), who found that many counterfeit pesticides pass through Nigeria on their way to Cameroon. The consequences of this failure to strictly apply the regulations in force in Cameroon are: the presence of counterfeit, under- or over-dosed products on the market, which cause a loss of effectiveness during crop treatment phases and contribute to resistance phenomena of undesirable weeds in the field, insects, and, above all, potential risks to human health and the environment (Matthews et al., 2011).

The most frequently used pesticides, with the highest frequency of use, are applied between 02 and 04 times per production cycle, with a percentage of 72%. This result can be explained by the fact that in these areas, undesirable weeds have already developed resistance to pesticides, and farmers find themselves in a situation where they have to increase the quantities to eliminate as many undesirable weeds as possible. It is also noted that the majority of respondents comply with the pesticide manufacturer's application rates (69% of respondents).

Despite this compliance, there remains a real problem in choosing the correct pesticide for each type of crop. This is why pesticides that are intended for cereals, for example, are sometimes used on legumes, which are not banned on Cameroon’s pesticide registration list.

On the other hand, a study by Temple et al. (2024) shows that in Cameroon, 81% of farmers do not follow the recommended pesticide doses, 93.4% do not follow recommended application frequencies, and 87% ignore manufacturers’ instructions. What’s more, some farmers go as far as mixing pesticides containing different active ingredients. For example, they mix Roundup with Gramoxone, or they mix Roundup with petrol, and even mix Gramoxone with iodized cooking salt—all to boost their production and reduce weeds as much as possible. This result corroborates the work of Olina Bassala et al. (2015), where, in the localities of Pandjama and Mafa

Kilda in the commune of Garoua 3 in Cameroon, mixing pesticides with natural substances such as salt limits the occurrence of undesirable weeds. Most of the pesticides used by farmers in the localities surveyed are systemic, targeting post-emergence weeds. However, some are selective, contact, and ingestion pesticides, targeting pre-emergence weeds, coprophagous caterpillars, and seed treatments. The pesticides listed above are classified in categories II, III, and U, according to WHO toxicity levels.

Analysis of the survey data reveals that farmers are well aware of the risks that the use of pesticides can cause to the environment, with impacts such as: the loss of biodiversity, changes in the existing landscape, and the general degradation of the environment, particularly grazing areas. Olina Bassala et al. (2015) found during their investigation that the use of pesticides in excessive doses can cause the death of plants, not only in the targeted areas but also outside them. Additionally, the major risk associated with pesticide use is the impact of these products on cropland, biodiversity, and the environment, leading to a decline in soil fertility (Cissé et al., 2003; Topan, 2005). In concrete terms, this is reflected in the increasing appearance of undesirable weeds.

Overdosing is the main cause of fodder contamination, followed by the volatilization of the herbicide applied in the field and poor use of the sprayer. It should be noted, however, that many farmers overdose on herbicides to increase their yields, as the soil has lost its fertility, and this is their best option. Regarding the volatilization of applied pesticides, given the proximity of agricultural fields to grazing areas, one cause of contamination may be volatilization during inappropriate applications (for example, wind or adverse conditions). It is also important to note that the treatment devices available to farmers are of poor quality, often resulting in liquid leaks and inadequate individual protection for farmers in the field (Diop, 2013).

According to Temple et al. (2024), 75% of farmers in Cameroon do not use personal protective equipment. The high cost of these treatment devices is a barrier to farmers replacing their equipment with newer, more suitable alternatives. Recent statistics show that, in Cameroon, only 25% of sprayers are considered suitable for use in the field (Matthews et al., 2003).

For all the farmers surveyed (100%), the use of pesticides had an impact on the quality of fodder in nearby grazing areas. Inappropriate behavior by animals upon their return from grazing, with numerous cases of illness, including coughing, diarrhea, paralysis, bloated stomachs, sores, vomiting, and other conditions (such as lung disease and respiratory illness), was observed. These different health conditions recorded in the localities surveyed corroborate the results found by Faye et al. (2010), Gomgnimbou et al. (2009), and Sawadogo (2016), who reported similar symptoms in humans working daily in agricultural plots or exposed to plant protection products. The correlation test conducted between the state of health of the animals and the pesticides used reveals that the averages of the groups are significantly different from one another. Therefore, the pesticide factor most commonly used by farmers has a significant effect on the state of health observed in the animals after their return from grazing.

For the majority of the farmers surveyed (98%), the use of pesticides has contributed to a reduction in grazing areas. The consequences of this are: a reduction in the fodder species highly valued by livestock, the almost total loss of fodder species that were once found but are no longer present, and even the degradation of the soil, which has led to the clearing of nearby areas—pastureland—making way for arable land.

Conclusion

At the end of this study, the general aim of which was to assess the effects of pesticide use in farming areas, 24 pesticides were identified. Several of these pesticides were found to be counterfeit (for example, Feodal Goal). Additionally, the doses/frequencies varied among farmers; some followed the manufacturer's recommended doses, while many farmers overdosed and even mixed several pesticides before applying them in the field. Regarding the causes of fodder contamination in grazing areas, 35% of respondents believed that overdosing pesticides in the field was the primary cause of contamination; 20% thought it was the volatile nature of the pesticide used, and another 20% attributed it to the poor use of crop treatment equipment, such as sprayers. Overall, 98% stated that the proximity of their fields to grazing areas is a major source of pesticide contamination. The majority of respondents (98%) observed inappropriate behavior in their animals after returning from grazing, particularly after pesticides had been applied in the fields. The various health conditions reported by farmers as being linked to pesticide use were: lung disease (54%), diarrhea (18%), mouth and leg sores (10%), runny nose (9%), belly bloating (4%), heart disease (2%), and paralysis (2%). To ensure the sustainable exploitation of natural resources found in grazing areas in the North Cameroon Region, while protecting the health of the population, reducing the risks of environmental pollution, and strengthening the protection of grazing animals, the study recommends that: the Ministry in charge of pesticide registration (MINADER) conduct regular visits to markets and points of sale for phytosanitary products, to train and raise awareness among retailers and producers on best practices in pesticide use; the State should combat the fraudulent entry of pesticides at the national level and strengthen the control system at phytosanitary firms; and growers should consider the technical frameworks more closely and explore the use of biopesticides in agriculture.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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