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CHARACTERIZATION OF WEED FLORA AND PESTICIDE USE PRACTICES IN VEGETABLE FARMING SYSTEMS IN PAKH AND MBANE, LAKE GUIERS REGION, SENEGAL

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ABSTRACT

Vegetable farming plays an important role in food security and farmers' incomes in Senegal. However, the intensification of production systems is accompanied by significant pesticide use, which can pose risks to human health and the environment. The objective of this study was to characterize the weed flora and assess pesticide use and management practices in vegetable farming systems in Pakh and Mbane, in the Lake Guiers area. A socioeconomic survey was conducted among 69 farm managers 37 in Pakh and 32 in Mbane using a structured questionnaire. Weeds were identified based on botanical criteria, and the pesticides identified were cross-referenced against the list of products approved by the Sahelian Pesticide Committee. The results revealed a weed flora consisting of 9 species, 8 genera, and 5 families, with a predominance of Poaceae and therophytes. All growers surveyed reported using pesticides. A total of 24 commercial products were identified, including 18 registered and 6 unregistered, representing 23 active ingredients or combinations of active ingredients. Compliance with recommended application rates was relatively high, while mixing pesticides, insufficient use of personal protective equipment, and improper handling of packaging were the main high-risk practices. These results underscore the need to strengthen phytosanitary oversight, promote integrated weed and pest management, and improve the management of pesticide packaging.

Keywords: Vegetable Farming; Weeds; Pesticides; Plant Protection Practices; Environmental Risks; Lake Guiers.

1 INTRODUCTION

Vegetable farming is an important activity in Senegal, contributing to food security, market supply, and farmers' incomes. However, its intensification particularly in the irrigated areas of the Senegal River valley and delta is accompanied by significant use of pesticides to control pests, diseases, and weeds. In Senegal, several studies have highlighted sometimes inadequate phytosanitary practices in vegetable farming systems, particularly in the North-western area, with potential risks to human health and the environment [1]-[2]. These risks are linked in particular to the misuse of products, the mixing of pesticides, insufficient use of protective equipment, and poor management of packaging.

This issue is of particular concern around Lake Guiers, Senegal's main freshwater reservoir and an essential resource for agriculture and the surrounding communities. A recent study on agricultural systems in the Lake Guiers area also confirms the prevalence of pesticide use on irrigated farms [3]. Across Africa, deficiencies in plant protection safety practices remain common and can increase farmers' exposure and the risks of environmental contamination [4]–[5].

Furthermore, weeds pose a major challenge to vegetable farming because they compete with crops for water, nutrients, and light [6]. Characterizing them is therefore essential for guiding integrated and sustainable weed management. In this context, the present study aims to characterize the weed flora and analyze pesticide use and management practices in vegetable farming systems in the villages of Pakh and Mbane, in the Lac de Guiers area. It focuses in particular on weed diversity, the pesticides used and their registration status, their origin, as well as practices related to mixing, adherence to dosage instructions, the use of protective equipment, and the management of packaging.

2 MATERIALS AND METHODS

2.1 Description of the lac de Guiers area

The study was conducted in the Lake Guiers area (15°55' and 16°23' N; 16°04' and 16°16' W), in the villages of Pakh and Mbane, at the boundary between the valley and the delta, near Richard-Toll, in northern Senegal [7]. Covering an area of approximately 250 km^2, it is Senegal's main freshwater reservoir. The lake is directly connected to the Senegal River through the Taouey tributary [8].

This resource plays a major role in agricultural activities and the socioeconomic development of the area. However, agricultural intensification linked to agribusiness, combined with climate change, is increasing environmental and socioeconomic risks for local populations.

2.2 The climate

The climate of the Lake Guiers region is Sahelian in nature, characterized by a short rainy season (about 3 months, from July to October), low annual rainfall (about 300 mm/year), which is unevenly distributed throughout the year and subject to significant year-to-year variability. During the dry season (November through June), temperatures are very high (averaging 30°C), relative humidity is low, and winds are strong and dry. In fact, the harmattan a hot, dry wind laden with dust and reaching speeds of 70 km/h predominates [8].

2.3 Soils and vegetation

The landscapes of the Lac de Guiers area exhibit a contrast between subarid, sandy soils and Take soils, which are either hydromorphic or halomorphic [9]. The highly permeable Diéri soils are associated with sparse steppe vegetation dominated by acacia, while the Take soils support herbaceous and shrubby vegetation. The lake's vegetation varies depending on soil type, water depth, and season, and includes species such as *Tamarix senegalensis*, *Acacia senegal*, *Hyphaene thebaica*, and *Adansonia digitata*.

Developments along the Senegal River Valley have promoted the growth of macrophytes, particularly *Typha australis* and *Phragmites australis* which cover more than one-third of the lake, as well as a high abundance of phytoplankton [10]. This plant species diversity plays an essential role in biodiversity, soil protection, climate regulation, and wildlife habitat [11].

2.4 Collection of socioeconomic data

Socioeconomic data were collected using a structured questionary that had been pilot-tested to improve its clarity and relevance. The questionary was then administered to farm managers who were selected as survey units because of their knowledge on vegetable farming practices. The collected data were entered and organized in Excel for processing. The

sample size was determined using the formula below [12], taking into account the total population and the margin of error.

$$Ne = \frac{n}{1+n/N}$$

- Ne = sample size,
- $n = 1/d^2$: degree of representativeness of the sample,
- d = margin of error,
- N=total number of households.

From a population of 557 farms, a sample of 69 farm managers was surveyed. The sample was divided between Pakh (37 farms) and Mbane (32 farms).

2.5 Identification of pesticides and weeds

The comprehensive list of pesticides authorized by the Sahelian Pesticide Committee (December 2021 version) enabled us to verify and identify which pesticides are registered in the ECOWAS subregion. The various weeds present on the site were identified based on previously established identification criteria [13].

2.6 Data processing

The survey data were entered and then processed using Excel to be presented in the form of tables and graphs.

3 RESULTS AND DISCUSSION

3.1 Origin of agricultural inputs

Agricultural inputs are primarily supplied through Richard-Toll where most producers both from Pakh (35 respondents) and Mbane (27 respondents) get their supply. Mbane is a secondary

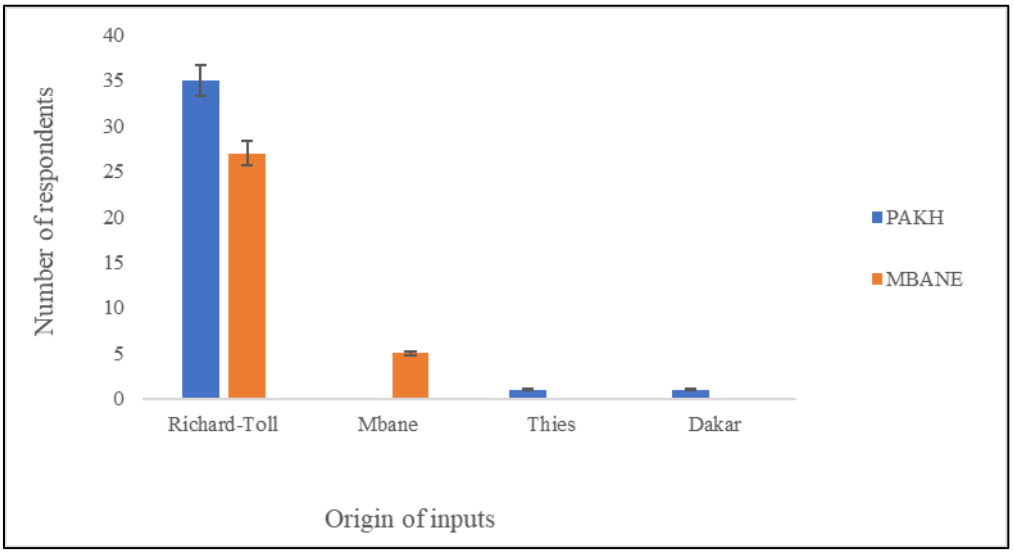


Figure 1: Origin of inputs

site of inputs supply with about 5 respondents (Figure 1). In contrast, Thiès and Dakar contribute very little to the supply. These results highlight the producers' heavy reliance on local supply chains, particularly the Richard-Toll market, likely due to its proximity and the availability of agricultural inputs.

3.2 Presence and types of weeds

The survey conducted in Pakh and Mbane identified 9 species belonging to 8 genera and 5 families, with the Poaceae family being the most prevalent including 4 species (Table 1). This dominance of grasses is consistent with studies conducted in Senegal, particularly in the Senegal River Valley and in various agroecological zones of the country, which identified 121 species of Poaceae weeds [6]–[14]. The dominance of the Poaceae may be linked to their strong ability to adapt to disturbed agricultural environments and their capacity to rapidly produce and disperse their seeds. The biological spectrum of our flora is dominated by therophytes (4 species), followed by hemicryptophytes (3 species).

These results are comparable to those reported by [14], who noted a dominance of therophytes and hemicryptophytes among weed Poaceae in Senegal. Similarly, [15] reported a strong dominance of therophytes (77.17%) in the weed flora of cowpeas in the northern part of the Peanut Basin. The low species richness observed in our study could be explained by local agroecological conditions and weed management practices. Despite this low diversity, certain Poaceae such as *Cenchrus biflorus*, *Brachiaria ramosa*, and *Pennisetum spp*. can cause significant damage due to their competition with crops for water, nutrients, and light. These results thus underscore the importance of integrated weed management tailored to local conditions.

Table 1: Weeds in the Pakh and Mbane area

Common names	Scientific name	Genus	Family	Organic type
Daga (Mâdé)	*Parinari macrophylla Sabine*	Neocarya	Chrysobalanaceae	Phanerophyte
kalè (Dyola)	*Gardenia triacantha DC.*	Gardenia	Rubiaceae	Chamaephytes
Diakhar (Wolof)	*Aristida longiflora Schum. et Thonn.*	Aristida	Poaceae	Hemicryptophytes
Khakham (Wolof)	*Ricinus communis L.*	Ricinus	Euphorbiaceae	Therophytes
kham kham (Wolof)	*Cenchrus biflorus Roxb.*	Cenchrus	Poaceae	Therophytes
kérèf (Pôl)	*Brachiaria ramosa Stapf*	Brachiaria	Poaceae	Therophytes
Mbop (Sérèr)	*Pennisetum pedicellatum Trin.*	Pennisetum.	Poaceae	Hemicryptophytes
Ndièmb (Wolof)	*Pennisetum violaceum (L.) A. Rich.*	Pennisetum	Poaceae	Therophytes
Niakhuri dèk (Wolof)	*Alternanthera nodiflora R. Br.*	Alternanthera	Amaranthaceae	Hemicryptophytes

D= Dyola Ds= Dyola-sud P= Pôl S= Sérèr T= Tâda W= Wolof

3.3 Pesticide use and diversity in the villages of Pahk and Mbane

The survey reveals that 100% of farmers in Pakh and Mbane use pesticides, confirming their heavy reliance on chemical pest control to protect their crops (Table 2). This widespread use is comparable to that reported by [16] in the vegetable farming systems studied. A total of 24 commercial products were identified, including 18 registered by the Sahelian Pesticide Committee (CSP) and 6 unregistered. Insecticides account for approximately 60% of the identified products, confirming the significance of pests in vegetable farming systems a trend also observed by [17] in Côte d'Ivoire. Organophosphates are among the most prevalent chemical classes, which calls for particular vigilance due to the toxicity of certain active ingredients. The presence of unregistered products also poses a potential risk to users, consumers, and the environment.

According to the WHO's toxicological classification, the majority of products fall into categories II and III, which correspond to moderately and slightly hazardous products, respectively. However, the risks also depend on the doses applied, the frequency of treatments, and the conditions of exposure. The diversity of the products identified thus reflects producers' heavy reliance on pesticides and underscores the need to strengthen integrated pest management (IPM) and promote alternatives to chemical control.

Table 2: List of pesticides used in the Pakh and Mbane area

N	Trade Name	Active ingredients	Chemical family	Targets	speculation	WHO class	Zone
1	ARSENAL 50 EC	Profenofos (500 g/l)	Organophosphate	Insecticide and acaricide	Tomato	II	PM
2	ATTAKAN C 344 SC	Cypermethrine (144g/l) +Imidaclopride (200 g/l)	Pyrethrinoïde +Neonicotinoïde	Insecticide	Cotton Plant	II	M
3	BAAZ	Lambdacyhalothrin 4.9 CS	Pyrethrinoïde	Insecticide	Cotton Plant	-	P
4	BASAGRAN	Bentazone (480 g/L)	Benzothiadiazoles	Herbicide	Onion	II	M
5	BELT EXPERT 480 SC	Flubendiamide (240 g/l) +Thiaclopride (240 g/l)	Diamide +Neonicotinoïde	Insecticide	Cotton Plant	III	M
6	BOMEC	Abamectine (18 g/l)	Avermectine	Insecticide and acaricide	Tomato	II	PM
7	BULLDOZER	Flubendiamide 20% WDG	Oxazolines	Insecticide	Tomatoes and Cabbage	II	P
8	CAÏMA B19	Emamectine benzoate (19,2 g/l)	Abamectine	Insecticide	Cotton Plant	II	PM
9	CALIFE 500 EC	Profenofos (500 g/l)	Organophosphate	Insecticide	Cotton Plant	II	PM
10	CALTHIO C 50 WS	Thirame (2 50 g/l) + Chlorpyriphos-ethyl (250 g/l)	Dithiocarbamate +Organophosphate	Insecticide and Fongicide	Cotton Plant	II	PM
11	DICHLOFORT	Dichlofort 100EC	Organophosphate	Insecticide	-	II	M
12	DIMETO 40 EC	Dimethoate	Organophosphate	Insecticide	All crops	II	PM
13	DRAGON	Chlorothalonil +Pyrimenthanil	-	Fongicide	Potato		P
14	ETOILE	Etoxazole (150 g/L)	Etoxazole	Acaricide	Vegetable Crops	III	P
15	FURADAN	Carbofuran	Carbamates	Insecticide	Rice and sugarcane	I	M
16	IKOKADIGNE	Haloxyfop-R methyl (104 g/l)	Organophosphate	Herbicide	Onion	II	M
17	K-OPTIMAL	Lambda-cyhalolhrine (15 g/l) +Acelamipride (20 g/l)	Pyretrinoïde +Neonicotinoïde	Insecticide	Cotton Plant	II	PM
18	MALIK 108 EC	Haloxyfop-R methyl (104 g/L)	Organophosphate	Herbicide	All crops	II	P

19	PACHA 25 EC	Lambda-cyhalothrine (15 g/l) +Acetamipride (10 g/l)	Pyrethrinoïde +Neonicotinoïde	Insecticide	Vegetable Crops	III	P
20	PYRICAL 480 EC	Chlorpyriphos-ethyl (480 g/l)	Organophosphate	Insecticide	Tomato	II	P
21	ROCKET	Chlorpyrifos 20% EC	Organophosphate	Insecticide	-	-	P
22	ROUNDUP POWERMAX	Glyphosate acide (360 g/L)	Organophosphate	Herbicide	Vegetable Crops	III	PM
23	ROUNDUP 680 BIOSEC	Potassium glyphosate (680 g/kg)	Organophosphate	Herbicide	Vegetable Crops	III	M
24	SAVAHALER	Methomyle	Carbamate oxime	Insecticide	Cabbage	III	M

Classe I : highly dangerous ; **Classe II** : moderately dangerous ; **Classe III** : slightly dangerous ; **P :** Pakh ; **M** : Mbane ; **PM** : Pakh and Mbane

Color Key:

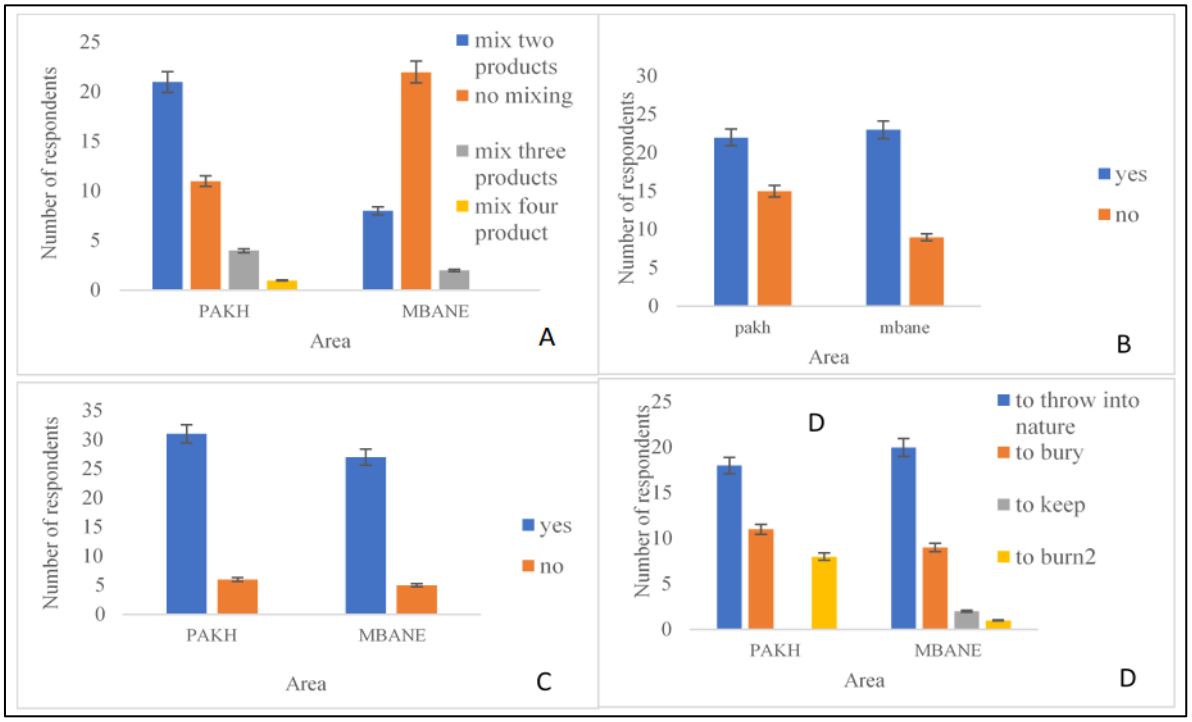
Product approved by the Sahelian Pesticide Committee (CSP) / CILSS

Product not approved by the Sahelian Pesticide Committee (CSP) / CILSS

3.4 Management and risks associated with pesticide use

3.4.1 Pesticide mixtures

The mixing of two pesticides is the most common in Pakh (21 growers), while the non-mixing approach is predominant in Mbane (22 growers); mixtures of three or four products remain rare (Figure 2A). This practice is intended, in particular, to control multiple pests simultaneously, but it can increase the risks of incompatibility, phytotoxicity, and exposure for users [16]. It should therefore be limited to combinations that are technically justified and recommended.



A: Mixing pesticides; B: Personal protective equipment; C: Adherence to pesticide application rates; D: Disposal of pesticide containers after use

Figure 2: Knowledge and Risks Associated with Pesticides

3.4.2 Use of personal protective equipment

The use of at least one item of personal protective equipment (PPE) is more common in Pakh (22 producers) and Mbane (23), but remains insufficient, with 40.5% and 28.1% of producers not using any (Figure 2B). This situation increases the risk of exposure during the preparation and application of pesticides and is consistent with the observations reported by [18] in Ouagadougou. These results underscore the need to raise awareness about the selection, use, and accessibility of PPE.

3.4.3 Compliance with pesticide application rates

Compliance with recommended application rates is relatively high in Pakh (83.8%) and Mbane (84.4%), reflecting a good understanding of the recommendations among the majority of farmers (Figure 2C). However, these results differ from those reported in [19] in Benin and [1] in Senegal, which noted frequent noncompliance with recommended application rates. Adherence to recommended doses helps limit the risks of phytotoxicity, residues, and soil and water contamination. Training on how to read labels, calculate doses, and calibrate equipment remains necessary, however.

3.4.4 What happens to packaging after use

Packaging management is the main weakness observed, with 48.6% of producers in Pakh and 62.5% in Mbane discarding packaging in the environment (Figure 2D). Landfilling accounts for 29.7% and 28.1%, respectively, exposing soil, water, and populations to contamination risks. These practices are consistent with the findings of [20] in Benin and [1] in the Niayes region of Senegal. The risks of contamination to aquatic environments and non-target organisms reported by [21]–[22] underscore the need for an organized system for the collection and safe disposal of packaging.

3.5 Risks of pesticides to human health and the environment

Farmers are more aware of health risks than environmental risks, with 28 versus 9 respondents in Pakh and 26 versus 6 in Mbane (Figure 3). This low perception of environmental impacts could be explained by the fact that such impacts are often diffuse and delayed. It is consistent with the observations in [1] regarding farmers' limited knowledge of

certain risks associated with pesticides. These results underscore the need to raise awareness about the long-term effects of pesticides on soil, water, and biodiversity.

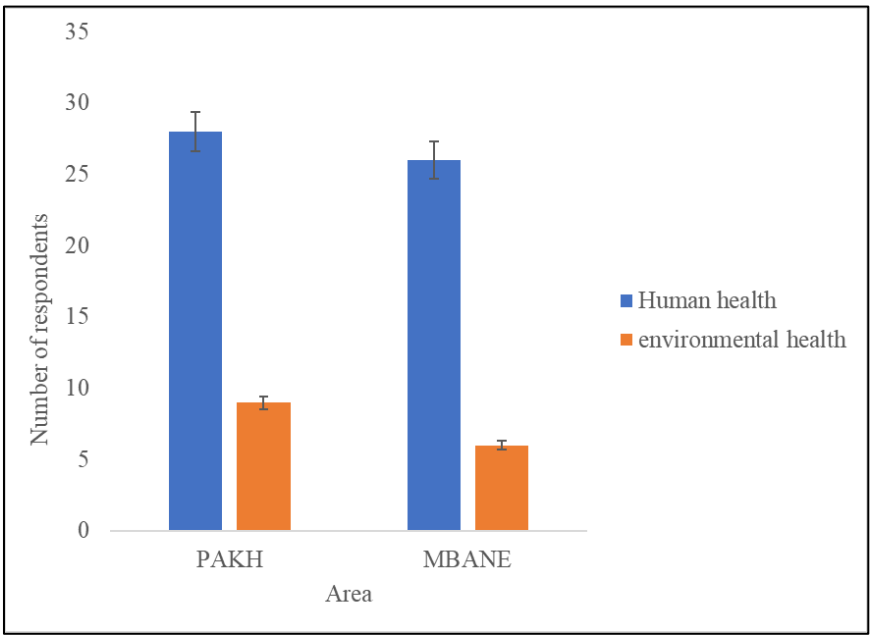


Figure 3: Potential risks of pesticides to human health and the environment

4 CONCLUSION

This study revealed a diverse weed flora consisting of 9 species belonging to 8 genera and 5 families, with a predominance of Poaceae and therophytes. It also showed widespread use of pesticides in the vegetable farming systems of Pakh and Mbane, with a wide variety of products, some of which were unregistered. Despite relatively satisfactory adherence to recommended doses, the mixing of pesticides, insufficient use of protective equipment, and, above all, poor packaging management cause risks to human health and the environment. Increased awareness and guidance for producers, the promotion of integrated weed management, and the implementation of a secure packaging management system are necessary to promote more sustainable vegetable farming in the Lake Guiers area.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare no conflicts of interest regarding this manuscript.

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