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Assessment of the Main Active Molecules among the most used Pesticides in the Gharb Region in Morocco

I. Maftouh[1, 2*], A. Moussaif [1], M. Elmzibri [1], N. Elabbadi [1] and A. Mesfioui[2]
[1] National Centre for Nuclear Energy, Sciences and Techniques (CNESTEN), Rabat, Morocco.
[2] Genetics - Neuroendocrinology and Biotechnology Laboratory, Ibn Tofail University, Faculty of Sciences of Kenitra, Morocco.
*Corresponding author email id: i_maftouh@yahoo.fr

Abstract **– During the last decades, the development of agriculture in Morocco has been accompanied by a massive use of plants' protection agents: insecticides, fungicides and herbicides. Moreover, the various epidemiological studies carried out throughout the world have evoked the involvement of these pesticides in several pathologies on people professionally exposed to. We also conducted a field investigation in the Gharb Region of Morocco, known as one of the country's main agricultural regions, to identify the most used active molecules and to assess the risk. The survey was carried out on the basis of a questionnaire addressed to companies importing and marketing phytosanitary products, public offices dealing with agriculture and some farmers. The data collected has revealed that among the 22 pesticides mentioned in the survey, insecticides account for 36% of the products marketed, while herbicides and fungicides account for 32% and 27% respectively. The survey showed that Chlorpyrifos - Ethyl is the major active substance used in this region among insecticides; the Paraquat and the Glyphosate are the most widely used herbicides. In the case of fungicides, the products used are very different and no active ingredient is mainly used by farmers. In view of these statistics, it is imperative to develop an integrated strategy for the efficient and rational use of pesticides in this region in order to limit the collateral effects of the massive uncontrolled use that would have negative effects on human health and the balance of the ecosystem.**

Keywords **– Agricultural Products; Gharb Region – Morocco; Pesticides; Survey.**

I. Introduction

Across the world, the development of agriculture is accompanied by a strong use of plants' protection products or pesticides which have shown their advantages particularly in increasing yields of production. However, these products have a negative impact on the environment, the quality of agricultural products, and the health of populations. Indeed, the World Health Organization (WHO) estimates the number of poisoning deaths related to the use of pesticides annually to more than 200,000 people [1].

In Morocco, recent data has indicated an increase in poisoning by pesticides. Also, the number of reports of pesticide's poisoning cases rose from 1296 cases in 2013 to 1351 in 2014 and to 1451 cases in 2015 [2]. This is mainly because of the poor practices by users, marketing and distribution systems that do not take into account the harmfulness of the compounds. In addition, the ignorance and/or the lack of awareness among users and consumers about the harmful effects of pesticides on health and the environment, the use of inadequate equipment during treatment, the absence of personal protection and non-compliance with recommended doses, can lead to direct poisoning by different ways (ingestion, contact, inhalation,...).

In Morocco, agriculture is an engine of economic growth and an effective tool for combating rural areas poverty. The useful agricultural area is estimated at about 8.7 million hectares. It has a wealth of agro-climatic systems that enable it to produce a very wide range of agricultural products. This agricultural area is subdivided into 5 agro systems according to climate, soil type, agricultural production, etc. In the "Bour favorable" agro system, the Gharb region represents one of the major agricultural areas [3].

The climate of the Gharb region, its water resources in addition to good quality and the diversified nature of its soil, have allowed a great development of the agricultural sector, which also relies on the existence of an important labour force and which benefits from the geographical proximity of major consumer centres and the European space [4], [5].

Because of the agricultural intensity and diversity of crops, the Gharb region is one of the agricultural regions that use several varieties of pesticides and in large quantities. The excessive use of pesticides, fertilizers and manure constitutes a real danger for the consumer of agricultural products and represents an enormous risk for the degradation of water's quality of his water table [6].

Thus, we planned to carry out a survey in this region in order to determine the most used pesticides. The objective of this survey is to provide a data on these pesticides, their use and toxicity, so as to propose integrated and concerted approaches to improve pesticides' management, risk reduction, their detection, their use for productive, and sustainable agriculture.

II. Materials And Methods

A. Gharb Region of Morocco

The Gharb region is a coastal region in the north-west of Morocco. It covers an area of 7 990 km², or nearly 1.1% of the area of Morocco. Its population is enumerated in 2014 to 1.904.112 inhabitants. It is part of Rabat-Sale-Kenitra region, according to the new administrative division of the Kingdom of Morocco [7]. According to this new division, the Territorial Agricultural Unit of the Gharb (UTA), is delimited to the west by the Atlantic Ocean and is surrounded by the other agricultural regions of Tangier-Habt, South Rif, Pre- Rif, Sais and Zaer-Zemmour (Fig. 1) [3], [5], [8].

In terms of relief, the Gharb region is characterized by the existence of three main zones illustrated by the map of Fig. 1. Indeed, the region has a large and rich central plain,

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bounded on the west by the coast and on the north by the

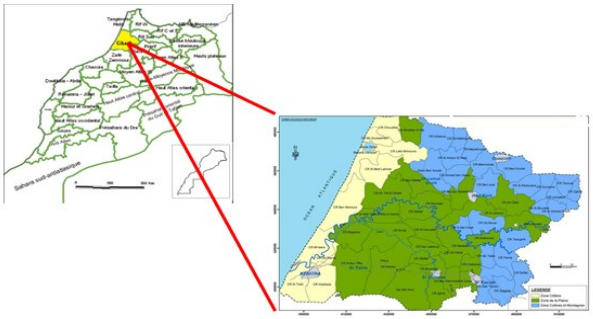

Fig. 1. Geographical location of the of the Gharb region

Pre-Rif, separated by a dune cordon, and to the south by the Maamora forest [8].

The Gharb region is characterized by abundant rainfall exceeding the national average. In addition, the climate of the region is of the Mediterranean type, soft and humid in winter, and hot and dry in summer. Water resources in the region are very large and diverse. Indeed, the groundwater of the region is formed by a deep water table which circulates in the Quaternary formations of the plain as well as the Maamora aquifer. Also, the region is crossed by Oued Sebou and three of its tributaries (Ouergha, Beht and Rdom), which constitute the main superficial resources. There are also important natural and biological reserves such as Lake Sidi Boughaba, Maamora and Merja Zerka [4], [8].

B. Data Collection and Analysis

The survey was conducted in April 2015 with the companies' marketing phytosanitary products, with the three public offices acting in the field of agriculture; namely the Gharb Agricultural Development Regional Office (ORMVAG), the National Institute of Agricultural Research (INRA) and the National Office for Food Safety (ONSSA); and some farmers.

A questionnaire, inspired by the work of Oudebji [9], was used to collect information from pesticide marketing companies, government agencies and users. This questionnaire is based on the collection of information relating mainly to the dominant crops of the Gharb region and the plants' protection products used there.

III. Results

Through this survey and information gathered, we found that the cereal crop is the main characteristic of the region and represents 57.83% of the cultivated area in this region (Fig. 2). Other crops such as sugar crops, oilseeds, market gardening, pulses and fodder crops are also important, accounting for 14.5%, 7.84%, 6.13%, 5.08% and 4.49%, respectively, of the cultivated area of the region.

This diversity of cultures prompted us to conduct research to determine the number and nature of the most widely used active ingredients in this region. Also, our investigation has shown the existence of five major licensed companies involved in importing and distributing phytosanitary products in the Gharb region. Three of these companies are in Kenitra, one of the major metropolises in the region, one in Souk El Had in the suburbs of the same city, while the fifth is located in the town of Sidi Slimane about 60 km northeast of Kenitra.

The analysis of the data, which has been collected clearly shows that insecticides are the main phytosanitary agents used. Insecticides account for 36% of the products marketed, while herbicides and fungicides account for 32% and 27%, respectively (Fig. 3). Data collected from marketing companies, in relation to the collected data from users and public bodies, reveals the use of 22 active phytosanitary substances. Among the insecticides used in the region, Chlorpyriphos - Ethyl is the most widely used active ingredient (Fig. 4), while Paraquat and Glyphosate are the most widely used herbicides (Fig. 5). In the case of fungicides, the products used are very different and no active ingredients are mainly used by farmers.

The phytosanitary analysis of the main active substances have been developed using the ONSSA phytosanitary index [10]. It has shown that these substances, which are present in several commercial products, are considered to be very toxic (Table 1).

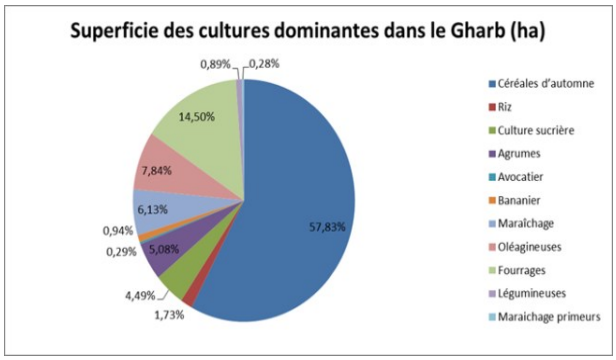

Fig. 2. Main crops in the Gharb region in 2015 [4]

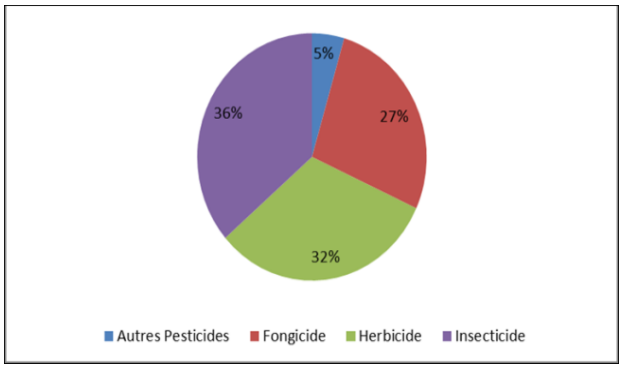

Fig. 3. The most used pesticides in the Gharb region

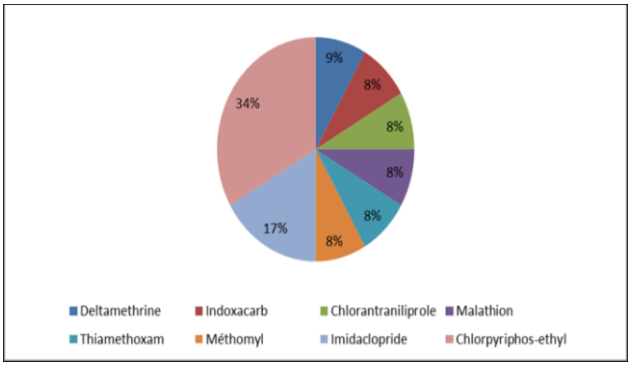

Fig. 4. The most used insecticides in the Gharb region

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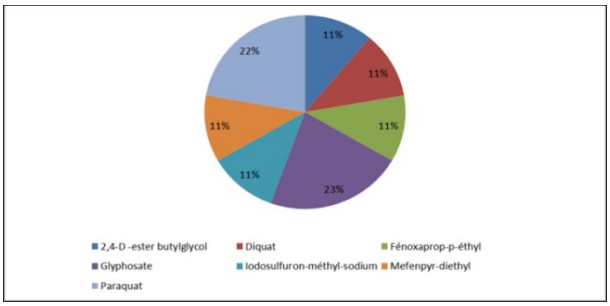

Fig. 5. The most used herbicides in the Gharb region

IV. Discussion

In the Moroccan Gharb Region, like other agricultural regions in Morocco, farmers regularly use the same fertilizers and plants' protection products, regardless of the crop grown during the year. They generally base their choice of crop protection products on feedback, on the advice of the resellers, and on crop yields. Moreover, the majority of farmers are illiterate or have a primary education. Thus, all these integrated factors can explain the massive and repeated use of pesticides in this region.

On the edaphic plane, the sandy nature of the soil of the region facilitates the infiltration of irrigation and rainwater into water table [8]. Thus, the massive and repeated use of phytosanitary agents in this region increases the concentration of these products in the soil causing the contamination of the water table and consequently has a negative phytosanitary and environmental impact. Moreover, the active ingredients are absorbed by the cultivated products, which can be destined for export and/ or for national human or animal consumption.

Across the world, most studies are converging towards the significant danger posed by the intensive use of these plant protection products, which, because of their toxicological power and persistence in soil and water, have a detrimental effect on the health of consumers [11], [12]. Recognizing the seriousness and consequences of the problem, Morocco, like other countries around the world, has implemented laws to regulate the marketing and use of plants' protection products and the maximum residue limit (MRLs) in products for consumption in addition to the Acceptable Daily Intake (ADI) [13].

To this end, the Chlorpyrifos - Ethyl ADI, revealed by our survey as the most widely used insecticide in the Gharb region, is estimated at 0.001 mg/ Kg/ day [14]. Also, the Moroccan regulation places the MRL of this product between 0.05 and 0.5 mg/ kg, depending on the agricultural product [13]. This molecule belongs to the family of Organophosphates known as acetyl cholinesterase inhibitory neurotoxins, an enzyme very important for the functioning of the nervous system [15].

Our survey has also shown that Glyphosate and Paraquat are the active substances mostly found in the herbicide preparations used in the Gharb region. Glyphosate is a non-selective total herbicide that is part of the amino acid family (phosphonoglycine) [16]. Its ADI is set at 0.025 mg/ kg/ day [17] and its MRL at 0.02 mg/ kg [13]. It is a neurotoxic and carcinogenic substance. For this reason, the European Food Safety Authority (EFSA) has provisionally extended the marketing authorization for glyphosate until June 2016, pending the finalization of the peer review of the European Union [18].

Paraquat belongs to the family of bipyridine. It is a quaternary nitrogen compound since the 4, 4' - bipyridine is its main precursor [19]. Its ADI is set at 0.004 mg/ kg/ day [20] and its MRL varies between 0.05 and 5 mg/ kg [13]. It is a very toxic substance, by inhalation and dermal, both for humans and for animals. To this end, this substance has been banned in the European Union since 2007 [21]. It is unfortunately still marketed in Morocco.

In addition, to verify that the ADI and MRL values are met by producers, authorities and certain analytical, control and research laboratories, use conventional chromatographic techniques (HPLC - MS, GPC - MS,...). These analytical methods remain relatively expensive in addition to the need for skilled personnel to analyse the samples. They are not very effective since they generally do not detect metabolites resulted from degradation of active substances [22]. As a result, recovered values are often underestimated and do not reflect the actual content of pesticides in soil and agricultural crops.

Again, pesticide metabolites are often more toxic and persistent than the parent compounds and have a direct impact on the environment [11]. The development of more effective and sensitive alternative methods is therefore of paramount importance in order to have reliable tools for the detection and determination of both pesticides and their derivatives. In this sense, immunological techniques are the tools of choice for the evaluation of residues of active ingredients in agricultural products. These techniques have the advantage of being simple to implement.

Table 1. Main characteristics of the most used active Molecules [10].

Active Molecules	Number of trademarked products	Content and Formulation	Toxicological class
Chlorpyriphos-Ethyl	46	480g/l (EC); 750g/kg (WG); 200g/l (CS); 5% (GR)	A / C
Glyphosate	14	60-180-360-450-480 g/l (SL); 250-360g/l (SC);	C
Paraquat	3	132-180-200 g/l (SL);	A

A: Acute; C: Chronic; CS: Suspension of capsules; EC: Emulsifiable concentrate; GR: Granulated; SC: Concentrated suspension; SL: Soluble concentrate; WG: Granulated to be dispersed in water

V. Conclusion

The agricultural region of Gharb (west of Kingdom of Morocco) is confronted with excessive use of pesticides and industrial fertilizers which is manifested by the accumulation in the soil and in the groundwater of nitrate and phosphate derivatives and active phytosanitary molecules. Therefore, its ecosystem is considerably threatened as well as the health of its consumer population. For that reason, a field survey was carried in order to determine the phytosanitary substances mostly used among insecticides, herbicides and fungicides. 22 products were identified during this survey, including 36% of insecticides, 32% of herbicides and 27% of fungicides. In addition,

Chlorpyrifos - Ethyl has been found to be the most widely used insecticide in this region, while Paraquat and Glyphosate are intensive used herbicides. For fungicides, farmers use a wide variety of products.

In view of the findings, it is imperative to develop an effective and efficient strategy to put in place the necessary measures to better management of the use of pesticides in this region and limit their damage to the health of consumers. This can be achieved by communicating more about the harmful effects of pesticides, ensuring awareness-raising campaigns with marketing companies and farmers, preventing the traffic and the use of prohibited active substances, and by carrying out regular surveys in order to assess the evolution of the situation in the region and to assess the impact of cultural habits on the environment and the health of consumers.

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AUTHORS' PROFILES

Ms. I. Maftouh has obtained her M.Sc. in Agro-Resources Valorisation in 2011, from the Ibn Tofail University, Faculty of Sciences of Kenitra, Morocco. She is preparing a PhD dissertation at the Genetics - Neuroendocrinology and Biotechnology Laboratory at the same Faculty in collaboration with the Biotechnology and Bio-Molecular Engineering Unit of the National Centre of Nuclear Energy, Sciences and Techniques (CNESTEN-Morocco). Her current research interests deals with the development of new methods for analysis and dosage of pesticides.

Dr. A. Moussaif is researcher in the field of Organic and Medicinal Chemistry at the Biotechnology and Bio-Molecular Engineering Unit of the National Centre of Nuclear Energy, Sciences and Techniques (CNESTEN-Morocco). He has got his PhD thesis in Pharmaco-Chemistry in 2002 from the Mohammed V University, Faculty of Sciences of Rabat, Morocco. Presently, he is interested in developing tools of immunoassay of small molecules.

Dr. M. El Mzibri is the Head of Life Sciences Division at the National Centre of Nuclear Energy, Sciences and Techniques (CNESTEN-Morocco). In 1996, he has obtained his PhD in Molecular biology, Cell biology and Microbiology from the Aix - Marseille II University, France. He is an expert in biotechnology, molecular biology and microbiology. He has conducted many research projects, supervised many PhD theses, published a lot of papers in international journals and given several lectures in these scientific fields at many international meetings and conferences.

Dr. N. Elabbadi is the Head of the Biotechnology and Bio-Molecular Engineering Unit of the National Centre of Nuclear Energy, Sciences and Techniques (CNESTEN-Morocco). She has received her PhD in Biochemistry in 1991, from the Aix - Marseille III University, France. Actually, she manages several projects in the fields of biochemistry and applied biochemistry.

Prof. A. Mesfioui is a professor and the director of the Genetics - Neuroendocrinology and Biotechnology Laboratory at the Biology and Life Sciences Department at the Ibn Tofail University, Faculty of Sciences of Kenitra, Morocco. He has received his PhD in Neurosciences in 1998 from the same Faculty. He has supervised many PhD theses, published a lot of papers in international journals, animated many international symposia and given many plenary conferences.