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Practical evaluation of phytosanitary products and environmental health risks in the Ziban region (Southeast Algeria)

Mohamed Omar Cheiakh [1,2], Kamel Guimeur [1,2], Fateh Mimeche [3+] and Belkacem Boumaraf [1,2]

[1] Department of Agricultural Sciences, University of Biskra, Biskra, 07000, Algeria

[2] Laboratory of Ecosystem Diversity and Dynamics of Agricultural Production Systems in Arid Zones, University of Biskra, Biskra, 07000, Algeria

[3] Faculty of Sciences, Department of Agricultural Sciences, University of M'Sila, M'Sila, 28000, Algeria

Abstract. *This study assesses the knowledge and practices associated with pesticide use in a farming community. To assess the potential risks to human health and the environment posed by the phytosanitary practices of farmers in rural three localities in the Ziban region, a survey of 103 randomly selected greenhouse growers was performed between December 2019 and January 2020. The results revealed that 100% of greenhouse farmers did not undertake any protective measures (full clothing) from preparing the spray mixture to the end of the treatments. In addition, 67% of greenhouse growers dispose of sprayer-rinsed water on the ground next to the water source (irrigation borehole). Greenhouse growers dispose of 71.8% of pesticide packaging in the wild and burn 6.8% on the farm. The findings of this study reveal that the phytosanitary practices followed by greenhouse growers in the Ziban region are poor and could potentially threaten the health of applicators, consumers, and the environment.*

Keywords: pesticide, practice, farmers, environment, Health.

JEL Codes: Q53

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+ FATEH MIMECHE. *E-mail address*: fateh.mimeche@univ-msila.dz .

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1. Introduction

The Ziban region is recognized as an agricultural pole, given its large area and production potential. This region supplies various agricultural products to the national and international markets (Guimeur, 2018). Nowadays, plasticulture in this region is one of the main intensive farming activities, ranking first at the national level (Bedjaoui, 2007; Ramdani, Tahri & Belhadi, 2009). However, greenhouse use constitutes an ideal environment for various crop pests (Nicot, 2008). Indeed, controlling crop pest species has always been a growing concern regarding crop protection and environmental contamination associated with greenhouse production in the region (Bettiche, Grunberger & Belhamra, 2017; El Mouden, 2010). These chemicals control or eliminate all undesirable organisms (plants, animals, fungi, or bacteria) (Al-Wabel et al., 2016). This action reduces endemic diseases transmitted by insects by protecting and restoring the plantations (Cisse et al., 2021; Ecobichon, 2001), thus contributing largely to the increase of yields and the regularity of production (Aubertot et al., 2005). Overall, the Algerian pesticide market represents 6.1% of Africa, representing only 4% of the global market (Belhadi et al., 2016).

Agricultural growth is associated with the use of phytosanitary products or pesticides all over the world. Admittedly, the use of pesticides has shown benefits. However, these products are harmful to the environment, as demonstrated by several authors in different countries, indicating the presence of pesticide residues in various environmental components, such as air, soil, and underground water (Schott, Mignolet & Benoît, 2004; Kaichouh et al., 2007) several years after their application (Rahmoun et al., 2018). Moreover, they represent a threat to crop quality and human health. Concerning this last point, the World Health Organization (WHO) estimates that more than one million people are victims of intoxication annually, causing the deaths of twenty thousand individuals (El Mouden, 2010). Pesticides also harm animals and ecosystems (Ramdani et al., 2009). These health and environmental risks are accentuated because roughly 30% of pesticides marketed in developing countries do not meet international quality standards (Diop, 2014).

Therefore, one of the principles of this activity is the evaluation and selection of personal protective equipment (PPE) used in the workplace. PPE is designed and manufactured to protect the user from potential work-related hazards or as a barrier to prevent the user from becoming a source of contamination (Desjardins-David, 2010). According to FAO and WHO 2021 reported details to obtain an accurate assessment where risk mitigation measures require the wearing of PPE, they provide technical information on the types and choices of PPE, appropriate, presenting different descriptions and illustrations of recommended protective clothing such as suits, shoes, gloves, goggles, face masks, and respirators. Accordingly, this work aims to study the use of pesticides by farmers and their adverse effects on human and environmental health.

2. Methodology

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2.1. Study area

The Biskra department (Ziban) is located in the southeast of Algeria (Aissaoui, 2019), comprising twelve daïra and thirty-three communes. The Ziban region has an arid Mediterranean climate, characterized by hot and dry summers, the average annual rain-fall is 361 mm, and evapotranspiration is 1,125 mm (Nouidjem & Mimeche, 2021). The study occurred in three regions of the wilaya: Braniss, El Ghrouss, and Sidi Okba. The sites were chosen based on their geographical locations: southeast, west, and south. The dominance of plasticulture and the intensive use of pesticides in this sector marks the selected regions.

2.2. The survey process.

The first phase was a field survey during the agricultural session, conducted from December 2019 to January 2020. The survey included 89 questions, considering the types of harvested crops, greenhouse crops, and phytosanitary treatments. The different questions deal with issues related to the use of pesticides and their adverse effects on human health and the environment. The survey followed a random scheme. However, we focused on farmers who grow vegetables in greenhouses to gather as much information as possible about our subject.

2.3. Data collection and assessment

Following the field survey, the data collected were coded and inputted with SPSS® version 25.0 (Statistical Package for Social Science). The descriptive results were expressed in frequencies and percentages for the categorical variables and, as a function of the number of farmers (individuals), then transferred onto the Microsoft Excel® 2007 spreadsheet

3. Results and Discussion

3.1. Farmers economic-social life

The survey counted 103 respondents in the three regions. They were all male farmers, mostly over 40 years of age (53.4%), and young farmers between 30 and 40 years of age represented (35%) (Table 1). These results are similar to those of (Cisse et al., 2021) in Senegal. All of them use pesticides. The survey reveals that the 41 participants (39.8%) are at the Middle educational level, as opposed to the university level, representing only 6 (5.8%). Moreover, the farmers at the primary or Quranic school level rank second with 25 (24.3%), followed by the producers at the secondary level 18 (17.5%) (Table 1). Similar results were reported in Biskra by (Rahmoune et al., 2018) and in Ecuador by (Hurtig et al., 2003). Regarding the experience of the farmers, it was observed that 53.4% of the greenhouse farmers have experience between 6 and 10 years in plasticulture. However, most of them (84 farmers) had been applying pesticides for years, ignoring the information on the pesticide packaging. This is probably due to the difficulty in understanding the information, safety procedures, and directions for use on the product labels. In particular, the instructions are in French, compared to their school levels. Indeed, the majority have an average educational level (39.8%). This observation was confirmed by a study in Ecuador (Hurtig et al., 2003).

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Table 1: Farmer's economic-scocial life

	Number of farms	Percentage (%)
Age		
20-30 years	12	11.7
31-40 years	36	35.0
More than 40 years	55	53.4
Education level		
Illerterate	13	12.6
Quranic school/Elementary school	25	24.3
Average level	41	39.8
Secondary school	18	17.5
University	6	5.8
Greenhouse farmers' experience in plasticulture		
1-5 years	35	34.0
6-10 years	55	53.4
More than 10 years	13	12.6
Farm structure by field of activity		
Vegetable crops	58	55.63
Cereals	13	15.11
Palm trees planting	23	21.77
Trees planting	9	7.5

The planted areas comprise vegetable crops 55.63% and leafy vegetables, as the predominant activity in this area. Nevertheless, another study in Morocco showed that cereal cropping is dominant (Naamane *et al.,* 2020). The latter is about 15.11% after vegetable crops, while tree growing is totally absent (Table 1). Six species cultivated in the soil have been inventoried. These species are entirely distributed in the local and national markets as follows: tomatoes 84.5% (*Lycopersicon esculentum* M.), chilli peppers 7.8% and bell peppers 3.9%, (*Capsicum annum* L.), melon 25.2% (*Cucumis melo* L.), zucchini 13.6% (*Cucurbita pepo*), and cucumbers 36.9% (*Cucumis sativus*).

3.2. Equipment and measurement tools

The devices used mainly were backpack sprayers with a capacity ranging from 16 L 52 farms (50.5% of cases) and a little use of tankers capacity of 100 L 4 farms (3.9%). Despite this, category 5 farmers (4.9%) do not use phytosanitary treatments. Instead, these apply a system of fertigation represented by (89.3%) of

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inquiries. For the measuring tools, there is the doser called (Kiala equivalent 5 ml) used by 35 farmers (34%) respondents. However the bottle cap is used as a measuring device more commonly in the area by 47 farmers (45.6%) because of this traditional and easier tool, 56 (54.4%) of the participants do not respect the recommended concentration.

Table 2: Treatment materials and frequency

	Number of farms	Percentage (%)
Proportion of treatment means		
No Material	5	4.9
Dosing sprayer	52	50.5
Water tank	4	3.9
Pomp engine	42	40.8
Treatment Frequency		
Every 3 days	22	21.4
Every 4 to 7 days	33	32.03
Every 8 to11 days	26	25.2
Every 12to 15days	5	4.9
More than 15 days	17	16.5
Processing time		
7 a.m. to 9 a.m.	4	3.9
10a.m. to 12a.m.	16	15.5
From 1 p.m. to 3 p.m.	28	27.2
From4 p.m. to 6 p.m.	32	31.1
No particular period	23	22.3
Proportion of personal protective equipment		
Overall	10	9.7
Gloves	26	25.2
Protection glasses	7	6.8
Muffs (muffler)	46	44.7
Mask	4	3.9
Boots	57	55.3
Residue of phytosanitary product after treatment		
I diversify it on the ground	69	67.0
I keepit in the sprayer for possible reuse	34	33.0

The water from cleaning the backpack sprayers is poured on the ground, near the water source, by 66% of the greenhouse growers. About 22.3 % of them spray the water from the cleaning on already treated crops. Only 11.7% of respondents rinse their sprayers. The greenhouse owners mismanage the water used to clean their sprayers, ignoring good practices and the harmful effects of these chemicals on the environment. Many respondents have at least one backpack sprayer as part of their application method and a measuring tool for pesticide dosing. Moreover, the common disadvantage of using backpack sprayers is an increased risk of pesticide exposure through airborne contamination. Furthermore, measurement tools such as test tubes graduated caps, and spoons often replace dosing devices as dosing instruments.

The labelling information on a crop protection product is critical for the proper use of the product, as it specifies the potential dangers of the product and the safety advice to be followed. However, not all respondents use the doses specified by the manufacturer. Many farmers consider pesticides a guarantee of high yields and determine the dose according to the effectiveness of pesticides. This farmers' mindset was confirmed by a study in Biskra by (Rahmoune et al., 2018).

3.3. Treatment frequency and timing

According to the results, most of the greenhouse operators declared that the frequency of treatment varies according to the climatic conditions, the harvested crop, and the targeted pests. However, 33 farmers (32.03%) of them spray every 4 to 7 days (Table 2), in the evening from 4 to 6 pm, by 32 farmers (31.1%), followed by 28 farmers (27.2%) applying from 1 to 3 pm. In contrast, four respondents spray from 7 to 9 am (Table 2). Based on the results, about four farmers apply their pesticides from 7 to 9 am during winter. In comparison, most workers declare that during the summer season, they proceed earlier due to the high temperatures and the risk to farmers' health. This same observation has been reported by (Rahmoune, 2019). Most respondents' treatment frequency ranging between four to seven days, could increase the harvesting dangers due to a higher rate of the recommended registered dose (RH) applied on a hectare during a crop year. The registered dose is defined as the practical application rate of a product on a crop and for a target organism (biohazard) (Brunet et al., 2008).

3.4. Use of Personal Protective Equipment (PPE)

The term "PPE" applies to any device or means designed to be worn or held by a user to protect them from any risk likely to threaten their health and safety (OJEU, 2016). It is observed that 100% of farmers do not adopt any protective measures (full protective clothing). Indeed, ten farmers (9.7%) wear overalls, only 25.2% wear gloves, and 7 (6.8%) wear glasses. Unlike the boots, which are the most used by 57 (55.3%), followed by the muffs, 46 (44.7%) (Table 2), the masks are the least used by four farmers (3.9%).

Regardless of the personal protective equipment used (overalls, gloves, boots, mask, goggles, or nose cover), these are not explicitly designed for pesticide treatment operations. The lack of compliance with safety measures during pesticide treatment operations is reported by several authors in Ecuador (Hurtig et al., 2003), Greece (Damalas, Georgiou & Theodorou, 2007), and France. For instance, 6.9% of beekeepers applying treatments against varroa mites in the departments of Ardèche and Loire do not wear any protection (Fayolle Poncet, 2009). This is also the case in the United States (Carpenter et al., 2002; Perry, Marbella & Layde , 2002), the Ivory Coast (Doumbia & Kwadjo, 2009; Wognin et al., 2013), and Burkina Faso

(Mohiddin et al., 2015). In Morocco, a higher rate, albeit lower than this study, of 25% of greenhouse farmers process their crops with no safety measures (El Mouden, 2010).

3.5. Protective measures

None of the 103 greenhouse growers used full protective clothing during spraying or the spray mixture preparation. Instead, most of them wear their old, daily work clothes. The safety precaution most observed by farmers is wearing boots (55.3%). In contrast, studies in Senegal found that 44% used masks, followed by gloves (36%), overalls (36%), and boots (31%) (Cisse et al., 2021). In Togo, 48.04% did not protect themselves during treatments (Madjouma et al., 2009). In our case, about 44.7% used muffs.

Regardless of the pesticide hazard, those who wear only disposable gloves reach 25.2%. When treatments are completed, 51.24% of greenhouse growers clean their hands only.

A considerable number of farmers reported not using protective equipment regularly. The older farmers were not used to working in such conditions, and despite the training and recommendations, some refuse to change their operating procedures, unlike young farmers who are more likely to make efforts. Wearing gloves and overalls is very restrictive.

In addition, 48.5% of greenhouse workers surveyed reported smoking or eating food during the preparation of the spray mixture and treatments in the greenhouse.

The non-compliance with protective measures by the majority of greenhouse operators in this region is due, firstly, to a lack of awareness of the instructions as to the real dangers of the pesticide, and second, to the scarcity of these uniforms on the market, as well as the inadequacy of the uniforms offered by pesticide vendors and agricultural equipment to the temperatures prevailing in greenhouses (Belhadi et al., 2016).

3.6. Residue of phytosanitary product after treatment

Moreover, there is no area equipped for preparing the spray mixture and the sprayers' rinsing. These improper practices by farmers lead to a risk of contamination, pollution, and environmental effects. The dispersion and accumulation of pesticides in the soil are the origins of environmental contamination problems.

These results were confirmed by studies in France (Alonso Ugaglia, 2011) and Senegal (Ngom et al., 2012). Cleaning of plant protection equipment near water points can affect human and animal health (Devez, 2004). Thus, it is mandatory to neither dump the crop protection product nor the rinsing water into the sewer or near a water source to avoid such localized pollution (UPJ, 2016). In addition, rinse water should be dumped on the previously treated area or sprayed in a low-risk area away from water courses and sources.

The most common pesticides the farmers surveyed use include mainly acaricides and insecticides, and rarely herbicides, as farmers adopt plastic sheeting to control weeds.

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3.7. Respect the pre-harvest interval (PHI)

Another concern is that of the pre-harvest interval (PHI), especially for consumers. This interval expresses the number of days separating the harvest from the last pesticide application. (Kanda et al., 2013), in Togo, has found that 49% of vegetable farmers respect the PHI, which comprises between 7 to 14 days and 39% an interval ranging from 14 to 21 days. However, only 9% of vegetable farmers take less than a week. In contrast, a small percentage of farmers—3%—record 21 days. Furthermore, there are studies in Togo by (Madjouma et al., 2009) that point to this result, and the return period is not respected in our area, as detailed by (Samuel & Saint-Laurent, 2001) and (Schiffers, 2011).

Not to forget the re-entry delay, which is not respected in our area, as detailed by (Samuel & Saint-Laurent, 2001) and (Schiffers, 2011). This aspect is often ignored and represents a significant risk of contamination. With some phytosanitary products, it is necessary to respect a time delay between the treatment and when it is allowed to return to the crop. Most greenhouse farmers do not respect the pre-harvest interval, with 47.5% respecting a delay of only 1-5 days after treatment with a phytosanitary product (PPS).

The one week was respected by only 21.4% of the producers in the study region. In contrast, only 7.8% of respondents followed a 15-day delay between the treatment and harvest periods (Table 3). This practice of treating and harvesting crops without respecting the PHI exposes consumers to the risk of large amounts of pesticide residues accumulating in their bodies, putting them at serious risk.

The lack of respect for PHI can be explained by market expectations (i.e., market pressure) or by farmers' ignorance and lack of awareness due to their low literacy level, combined with the failure of outreach and sensitization activities. Occasionally, due to the absence of information when products are purchased in non-original packaging (without labels). This last case is represented by 55.3% in our sample.

This situation of non-compliance with PHI is described as common in developing countries. In addition, this yield harvested without respecting the PHI in Biskra is also recorded by (Belhadi et al., 2016), (Rahmoune et al., 2018) and (Ramdani et al., 2009) among greenhouse farmers in the localities of Ziban (Algerian Lower Sahara), Mziraa, El Grouss, Tolga and Sidi Okba in Algeria, and in Togo (Madjouma et al., 2009).

Table 3: Respect the pre-harvest interval

Respect the PHI	Number of farms	Percentage (%)
3 days	23	22.3
5 days	26	25.2
7 days	22	21.4
10 days	22	21.4

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15 days	8	7.8

3.8. Pesticides used

Four types of pesticides were identified: acaricides (35.9%) of various chemical groups, followed by insecticides (33%). The use of herbicides is limited to 9.7%, and only 21.4% of farmers use fungicides (Table 4). After application, farmers (71.8%) typically throw empty packaging in nature, only 6.8% burn them, and 13.6% dispose of them in the public dump, a percentage of 7.8 of them reuse the packaging for other purposes (Table 4)

3.9. Empty packaging management and storage conditions

Recycling and rational management of empty packaging are completely absent among all the respondents. The study findings demonstrate that the majority of the respondents, 71.8% discarded the empty packaging after use in the environment. These packagings are burnt by 6.8% of the surveyed greenhouse operators in the study area. This behaviour is motivated by the lack of knowledge of the negative effects on human and environmental health. Indeed. The incineration of empty packaging, especially those made of chlorinated products, generates toxic smoke and persistent organic pollutants (POPs) such as dioxins (Tchamadeu, Nkontcheu & Nana, 2017). Conversely, nearly 13.6% of our respondents dispose of the packaging in the public waste dump. At the same time, some respondents (7.8%) stated that they occasionally reuse the packaging for other purposes when necessary.

Therefore, the most significant risks to health and the environment are associated with empty packaging reusing, throwing away, or incineration. Belhadi, 2017 uncovered the poor management of empty packaging in Biskra, indicating that the majority of farmers threw the packaging into nature (43.2%) and burned it (32.6%). This alarming situation was also observed among the targeted farmers of several studies in South Benin (Ahouangninou, Fayomi & Martin, 2011), Togo (Kanda et al., 2013), Burkina Faso (Son et al., 2017), the Ivory Coast (Doumbia & Kwadjo, 2009), and Senegal (Ngom et al., 2012). For instance, in Senegal, there are cases of washing of crop spraying equipment and soiled clothing during treatments inside wells and uncontrolled dumping of packaging at the edge of and inside wells. The authors even report the reuse of packaging as food containers. Therefore, according to the results of these studies, the management of pesticide waste has a negative impact on the environment.

Table 4: Pesticide distribution by class and Management of empty packaging

	Number of farms	Percentage (%)
Pesticide distribution by class		
Fongicides	22	21.4

Insecticides	34	33.0
Herbicides	10	9.7
Acaricides	37	35.9
Management of empty packaging		
Burn	7	6.8
Thrown in the environment	74	71.8
Disposed in public dumpsite	14	13.6
Reuse for other purposes	8	7.8

Most farmers are not influenced by price or the proposed packaging. Only 8.7% declared an interest in the efficacy of the products over the price. Moreover, 37.9% of the greenhouse owners affirmed that the efficiency of the phytosanitary products is more important, followed by 24.3% who consider the certification as a determining factor in the purchase decision of the product (Table 5). Similar studies by (Aubertot et al., 2005) note and assert the previous results regarding pesticide use and quality, focusing mainly on farmers. Additionally, 37.9% of farmers choose the most effective pesticides regardless of price.

Table 5: Product purchase distribution

	Number of farms	Percentage (%)
Yes, the certification is a decisive factor for the purchase	25	24.3
No, the cost-quality ratio is more important	9	8.7
No, less expensive product are the most important	16	15.5
No, the most important is the strongest chemical against plant pests (more effective or aggressive)	39	37.9
No, the most important is the chemical suggested by the supplier	14	13.6

4. Conclusions

The vegetable farmers of Braniss, Sidi Okba, and El Ghrouss of Ziban region in Algeria are hardly literate, engaging in risky vegetable farming based on empirical behaviour regarding the use of pesticides and the management of adverse effects resulting from this use. Greenhouse growers focus mainly on chemical control, which shows its advantages by eliminating or reducing predators, especially in the case of greenhouse vegetable crops. Surveys indicate that the need to increase yields in the area led to the effective use of phytosanitary products.

A large proportion of the people in charge of these farms are over 40 years old, with little technical supervision due to the absence of pesticide use and management advisors. Therefore, our survey results indicated that it is imperative to identify and describe the problems associated with pesticide misuse and concerns about excessive and disrespectful pesticide use that leads to exposure of farmers to the risk of poisoning and can have adverse effects on the environment and human health. Also, we noticed during our survey, poor management of empty packaging that the farmers eliminate by incineration or disposal, which can be a potential sources of environmental pollution, as well as, not wearing the full protective uniform by farmers and non-compliance with the pre-harvest intervals that could induce harm to the consumer's health.

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