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AGROCHEMICAL PROTECTION PRACTICES FOR MARKET GARDENERS AND ENVIRONMENTAL RISKS ON FARMS IN BOUIRA (NORTHERN ALGERIA)

Abstract: Pesticides are used to protect crops against natural enemies. However, poor management of these products harms the environment and public health. The study aims to assess the use of pesticides on market garden crops in the Bouira region. We surveyed them to obtain as much information as possible and to identify current pesticide use practices for the varieties of plants grown in the region. We were able to determine 23 commercial brands, including 21 active ingredients. All the farmers interviewed used different types of pesticides, with rates of 84% for fungicides, 76% for insecticides, 44% for herbicides, and 20% for acaricides. When applying these products, farmers do not protect themselves properly; only 24% use the full kit. The management of empty packaging is haphazard. Most farmers (46%) burn empty packaging, 28% choose to deposit it in landfill sites, and 8% abandon it on their farms. Our results indicate the use of several active ingredients and a lack of respect for the rules of good agricultural practice.

Key words: pesticides, products harms, fungicides, insecticides, herbicides, acaricides

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Introduction

Agricultural production is faced with a variety of constraints, both biotic and abiotic, which affects it negatively. Harmful insects, phytopathogenic microorganisms such as fungi, viruses and bacteria, as well as other pests, are perceived as elements that restrict productivity. Plants fall victim to attacks at various stages of their growth (Tapwal et al., 2011). Thus, it is crucial to use pesticides and fertilizers in order to optimize agricultural productivity (Popp et al., 2013). In fact, pesticides are vital in agriculture for protection against biological disasters, crop productivity and steady yield growth (Products et al., 2020).

However, the indiscriminate and extensive use of pesticides represents one of the world's major environmental and public health problems (Khan & Rahman, 2017; Pimentel, 2005). Every year, pesticides claim the lives of 2000 persons in the developing world, and they have a major negative impact on 25 million agricultural workers because to their high bodily concentration (Boedeker et al., 2020). In Africa, these toxic products cause the most damage to people and the environment, particularly in rural areas (Andersson & Isgren, 2021). Studies on pesticide use practices indicate that unsafe pesticide use is commonplace in developing countries, and that demand for these products is growing because of the current high-yield agricultural production system. (Wesseling et al., 1997). In Algeria, little is known about the plant protection practices used by farmers.

There is very little accessible data; the few surveys revealed abnormal practices and the use of several unregistered pesticides in certain regions (Belhadi et al., 2016; Oultaf, 2022; Rahmoune et al., 2018).

The province of Bouira, known for its agricultural vocation (Lamri et al., 2020), has made significant progress in quality and quantity in the agricultural sector. According to National Agency for Land Intermediation and Regulation (ANIREF), Bouira region has significant agricultural potential, with an area of 189,960 hectares (Belarbi & Bouder, 2023; Lamri et al., 2022). This requires the use of various phytosanitary products to ensure optimum agricultural production.

Our study is a survey that highlights the state of pesticide use in market garden crops in the Bouira region. It focuses on the characteristics of market gardening, identifies the products used, their methods and the doses applied, and assesses farmers' knowledge and awareness of the environmental and health risks associated with pesticide use.

Materials and Methods

The survey was conducted among farmers in the Bouira region at four agricultural stations with significant vegetable crop production (El Esnam, Ain Bessam, Bouira and M'chedallah) (Fig. 1)). We used an appropriate questionnaire to gather as much information as possible, and to determine current practices in using phytosanitary products on market garden crops grown in the region.

To collect data for our survey, we visited the Sectoral Agricultural Directorate (SAD), the Chamber of Agriculture of Bouira province, and the subdivisions of M'chedallah and Ahnif to facilitate contact with farmers. Additionally, we conducted field visits during the

spring season to directly interview farmers, ensuring comprehensive responses to all questions. The questionnaire is structured into four main sections: the first gathers information about the farmers and the market garden crops they grow; the second explores the different agricultural products they use; the third focuses on the application methods and doses; and the fourth evaluates the criteria for product selection, the protective measures employed, and the management of waste and packaging.

Various international databases provide data on active ingredients, such as Footprint (Footprint database, 2022), SAGE Pesticides (SAGE Pesticides, 2022), and E-Phy (ANSES, 2022). In this study, data on active ingredients are taken from the European Footprint database (Footprint database, 2022). For each pesticide inventoried, the associated active ingredient(s), their chemical family and toxicological class (according to WHO) have been identified.

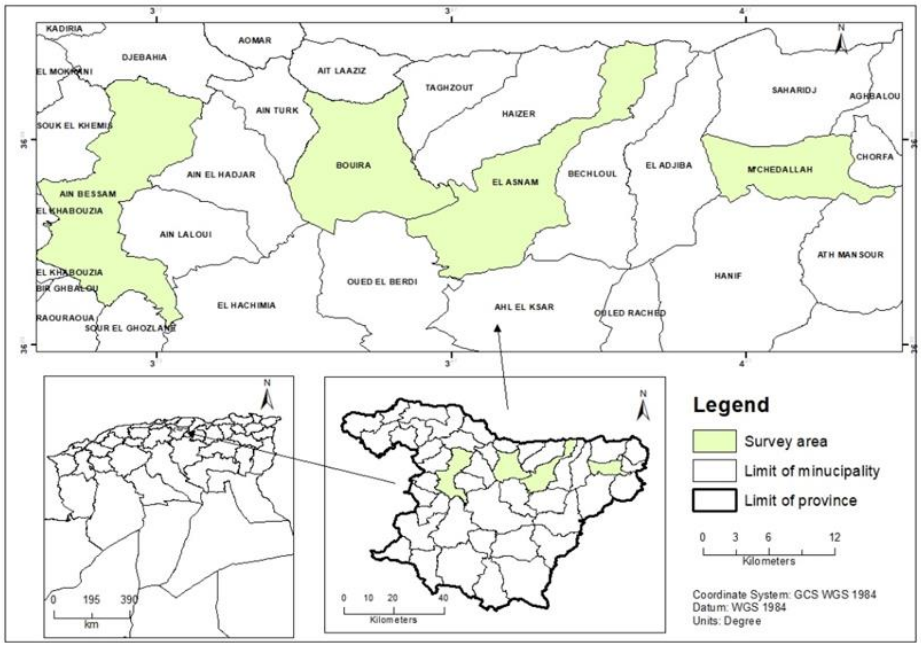

Fig. 1. Administrative map of the province of Bouira

Results and Discussion

Respondents' age and level of education

Results relating to the age of farmers show that the category (31-40 years) dominates with a rate of 40%. The category (61-70 years) is the least represented, with a rate of 6% (Fig. 3). 52% of farmers surveyed have secondary education. Of the farmers surveyed, only 20% had completed primary school. The percentage of farmers who have completed university studies is 16% (Fig. 3).

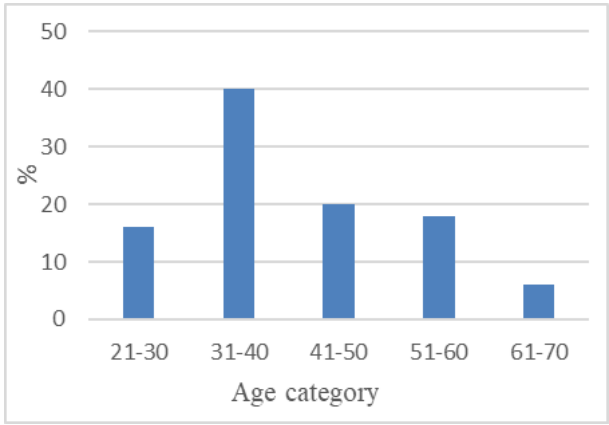

Fig. 2. Age of farmers interviewed (Data Source: survey results)

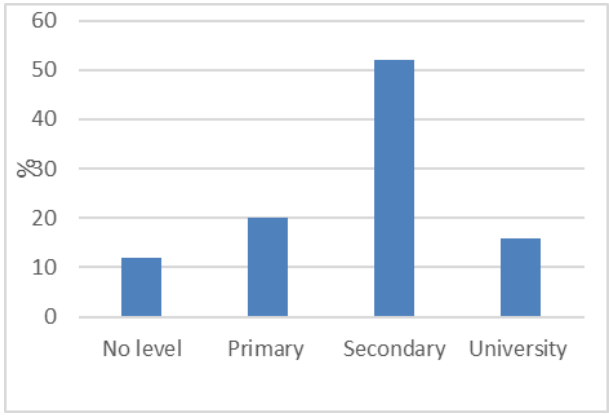

Fig. 3. Farmers' educational level (Data Source: survey results)

A study by Morillon (2016) in France revealed that the higher the farmer's level of education, the greater his level of knowledge regarding plant protection products. A study by Jean et al. (2019) showed that farmers' low level of education constitutes a great risk of intoxication for themselves and the environment, as they are unaware of the high toxicity of phytosanitary products.

Scheyer et al. (2005) note that the problem with pesticides lies in the way they are used. Indeed, most farmers are unaware of the risks of using plant protection products. They are ignorant of and do not comply with regulations, and handle pesticides unconsciously. In our case, the farmers interviewed stated that they had attended training courses and extension days on applying plant protection products.

Cultivated species

The study stations are characterized by several varieties of market garden crops, of which potatoes take first place with 72.07% of the utilized agricultural area. (Tab. 1). Figure 2 shows the general diagram of the distribution of groundwater. The Sakar horizon, belonging to the evaporite aquifer complex, has no tight fluid seals from the underlying Jurassic aquifer complex. It represents a buffer, transitional zone from evaporite to carbonate

aquifer complex. Along the section, there is a gradual distribution of pressure from higher to lower, and mineralisation and chemical composition of solutes.

Table 1. Most common crops grown in the study area (Data Source: survey results)

Cultivated species	Area as a percentage
Potatoes	72.07 %
Tomato	2.94 %
Lettuce	2.32 %
Onion	16.75 %
Wing	0.28 %
Peppers	4.23 %
Chili pepper	0.56 %
Cauliflower	0.84 %

Our results concur with those obtained by Omari (2011) in his study in the province of Ain Defla, who notes that most farmers grow potatoes (70%), with the remainder shared between vegetable crops. Similarly, Nesrine et al. (2023), in a pesticide use survey in the Oued Souf region, noted that potatoes are the most widely grown crop, followed by tomatoes and peppers.

Typology of pesticides used

Most farmers (86%) use pesticides regularly to protect their crops; however, a small proportion (14%) use pesticides occasionally in the event of heavy attacks by bio-aggressors.

Fungicides are used by 84% of farmers surveyed, followed by insecticides at 76%, herbicides at 44%, and acaricides at 20% (Fig. 4). These results show that the farmers surveyed use different types of pesticides. In fact, the application of these products depends on the farmer's objectives, and can be both preventive and curative.

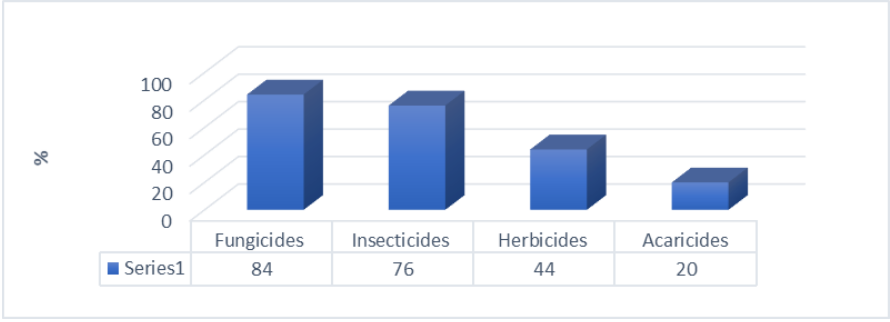

Fig. 4. Pesticide application rates (Data Source: survey results)

The farmers interviewed admit that they use several types of pesticides in different forms, sometimes mixing and alternating products to ensure effective treatment. In fact, during our survey, a total of 23 brand names and 21 active ingredients were identified. Tefluthrin is classified by the WHO as a very hazardous active ingredient (class Ib) (Tab. 2). Noting that Wen et al. (2020), Wang et al. (2023) has highlighted the ecotoxicity of this substance for human health, terrestrial and aquatic ecosystems.

The high use of fungicides (39.13%) is linked to the types of crops (market garden species), most often attacked by fungi. In this context, we recall that the potato is the most dominant crop in the study area, and is highly vulnerable to late blight. The use of pesticides is a very important factor in protecting the crop. It depends on the type of enemy present. The

farmers surveyed use insecticides and herbicides in significant quantities, with rates of 30.43% and 17.40%, respectively. This result can be explained by the fact that nowadays, biological control techniques against insect pests and natural weed control are omitted, and farmers all resort to chemical products. The latter are more effective and easier to apply.

In the Tizi-Ouzou region, Oultaf et al. (2022) report a usage rate of 50% for fungicides and 43% for insecticides, while herbicides are used at just 4%. In order to protect vegetable crops from bio-aggressive attacks, ensure the best quantitative and qualitative yields, and meet market requirements, all farmers interviewed attest to using a wide range of pesticides (Wang et al., 2023).

Indeed, according to Garrido-Miranda et al. (2022) and Barzman et al. (2015), pesticides reduce crop losses caused by pests and ensures yield stabilization.

However, pesticide residues in agricultural products can harm human health, as they are a food safety problem worldwide (Akoto et al., 2013; Berrada et al., 2010; Jardim et al., 2014; Mahdavi et al., 2022; Mehmood et al., 2021; Shammi et al., 2020; Yigit & Velioglu, 2020).

The farmers surveyed consider pesticide efficacy the first basic criterion for choosing their products, followed by recommendations by a farmer (depending on the species grown). They pay no attention to price, ease of use, or harm to nature.

Table 2. Pesticides used to protect market garden crops at the stations sites (Data Source: survey results)

Pesticides used	Trade name	Active ingredient	Chemical family	WHO class
Fungicides (39,13%)	Ortiva	Azoxystrobin	Strobilurins	U
	Consento	Fenamidone, Propamocarb	Imidazolinones+Carbamates	U
	Amistar top	Azoxystrobin	Strobilurines	U
	Aliette flash	fosetylaluminum	Phosphanate	U
	Banko	Chlorothalonil	Organochlorines derived from benzene.	U
	Azox	Azoxystrobin	Strobilurines	U
	Proplant	PropamocarbHcl	Carbamates	U
	Carial	Mandipropamid, Copper oxychloride	Carboxylicacid amide + Copper	U
	Agrixyl	Organochlorinesderivedfrombenzene.	Acylalanines	II
Insecticides (30,43%)	Pyrical	Strobilurines	Organophosphorus	III
	Match Gold	Carbamates	Benzoylureas	III
	Amipride	Carboxylicacid amide + Copper	Neonicotinoids	II
	Force	Tefluthrin	Pyrethroids	Ib
	Enjeo	Thiamethoxam+Lambdacyhalothrin	Syntheticpyrethroids	II
	Decis	Deltamethrin	Pyrethroids	II
	Previcure	Fosetyl-Aluminium, PropamocarbHCl	Carbamates	U
Herbicides (17,40%)	Goel	Oxyfluorfene	Diphenylethers	U
	Basta	Glufosinate-ammonium	Organophosphates	II
	Rophosate	Glyphosate	Phosphonoglycines	III
	Focus Ultra	Cycloxydin	Cyclohexane diones	III
Acaricides (13,04%)	Acarol	Hexythiazox	Thiazolidinones	U
	Promite	Propargite	Sulfite esters	III
	Agrithiazox	Hexithiasox	Thiazolidinones	U

Note: Ib = Highly hazardous; II = Moderately hazardous; III = Slightly hazardous; U = Unlikely to present acute hazard in normal use.

Protective equipment used by farmers

Farmers do not use very effective means of protection when handling plant protection products. Only 24% of farmers use a complete kit. The mask is the most commonly used means of protection, with a rate of 38%. Gloves are used by 26%, while only 10% wear boots. There is a small category that uses other means, such as goggles (Fig. 5).

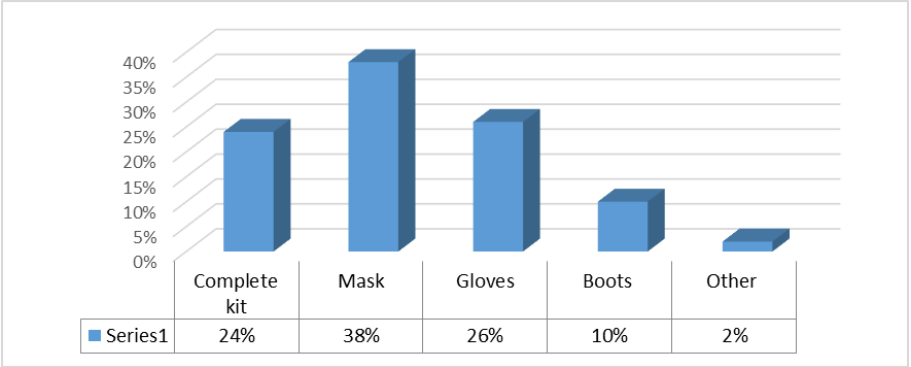

Fig. 5. Means of protection (Data Source: survey results)

Plant protection products are easily absorbed orally, dermally and through the respiratory tract (Damalas & Koutroubas, 2016; Products & Residues, 2013). Farmers do not adopt effective means of protection, using only masks and gloves. This neglect may be because farmers are unconvinced of the direct risks involved in handling plant protection products, the inconvenience of changing clothes, the lack of control over using these products, and/or the high cost of complete kits.

Our results are similar to those of Cissé et al. (2003) who note that over 85% of market gardeners have no protective equipment. The same observation was made in the study by Farahmandfard and Khanjani (2023) and Yang et al. (2014), who indicated that over 50% of farmers questioned said they had never worn protective accessories. Wade (2003) in Senegal showed that the lack of protective equipment increases the risk of intoxication. Naamane et al. (2020) note that all interviewed farmers use pesticides; 75% do not know how to use these products.

Several authors have noted exposure to their residues during pesticide use provokes users reactions such as eye discomfort, stinging, nausea, and skin reactions. The appearance and severity of these reactions depend on the toxicity of the products used and the protective measures followed. In addition to these short-term reactions, other abnormalities appear in the long term (cancer, endocrine disorders, and reproductive abnormalities can be observed in farmers) (Stava et al., 2007).

Packaging management

The farmers surveyed adopted different methods for managing packaging, with 46% saying they burn packaging after use, 28% throwing it into landfills, and 8% admitting to abandoning it on their farm (Fig. 6).

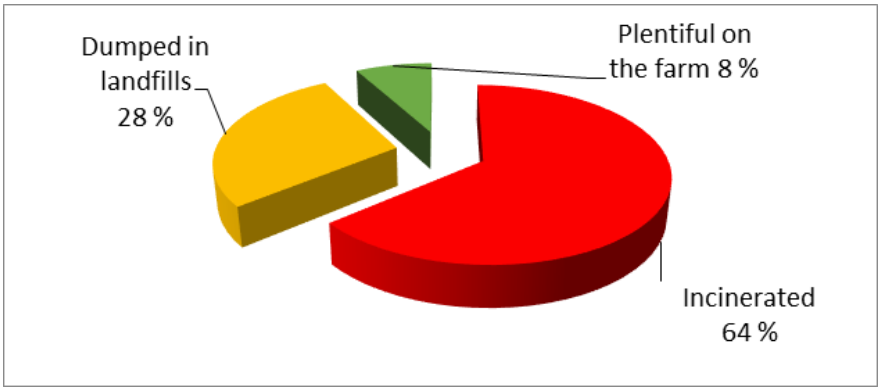

Fig. 6. Management of empty packaging (Data Source: survey results)

Empty pesticide packaging discarded in the natural or agricultural environment presents a high risk of contamination of water sources. Similarly, abandoning the packaging in the field is a risk for people and animals, who often graze the fields after harvesting (Elleboudt, 2012). Our survey showed that most empty pesticide packaging is burnt, some is disposed of in landfills, and some is abandoned in the environment.

Our results are close to those of Wade (2003) in Togo, where 20% of farmers dispose of packaging at landfill sites. At the same time, Kanda et al. (2013) demonstrate that the rate of farmers burning packaging is 52%. The lack of control over the methods used to treat agricultural products can thus affect aquatic and terrestrial ecosystems (Aktar et al., 2009).

Our results confirm those indicated by several authors, highlighting a lack of professionalism on farms. Indeed, Wesseling et al. (1997) and Cissé et al. (2003), in Africa Belhadi et al. (2016), Oultaf et al. (2022) and Oultaf et al. (2023), in Algeria have reported a massive and uncontrolled use of pesticides in agriculture.

Conclusion

This study is crucial as it highlights the intensive use and poor management of pesticides in market gardening within the Bouira region. Farmers in the main agricultural zones regularly use a wide range of pesticides, with fungicides being the most commonly used, followed by insecticides, herbicides, and acaricides. However, despite regulations, most farmers do not adequately protect themselves when handling these phytosanitary products. Additionally, packaging management is highly inconsistent, with many farmers choosing to burn empty packaging, dispose of it in landfills, or abandon it in the environment. These practices pose significant risks to human health and the environment. To address these issues, the implementation of good management practices is essential and more than necessary. This includes the proper use of protective equipment, responsible disposal of pesticide packaging, and the establishment of a monitoring system to control the impact of these products on environmental compartments and human health. By learning from this case, stakeholders can promote safer agricultural practices and work towards sustainable farming in the region.

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Conflicts of Interest: The authors declare no conflict of interest.

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