

# Assessment on Pesticide Knowledge and Usage by Apple Farmers in Foussana Delegation, Kasserine Governorate, in Center-West of Tunisia

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## ABSTRACT

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Apple farmers in center-west of Tunisia are heavily dependent on pesticides to ensure the phytosanitary protection of their orchards. The present study was carried out among the apple growers of the delegation of Foussana using face-to-face interviews to determine socio-demographic characteristics, status of pest management, their levels of knowledge of pesticide handling, their ability to understand the displayed instructions on product labels and the use of personal protective equipment (PPE). The results showed that farmers used 3 classes of pesticides in their orchards: insecticides (47.76%), fungicides (28.36%) and acaricides (23.88%) among them 96.3% were purchased from local retailers. About 25.61% of farmers declared reading always pesticide labels before application against 35.71% not reading it at all and 38.68% were indifferent. About 57.3% of interviewed farmers applied pesticides in mixture. Among them, 31.7% mix 2 pesticides, 20.7% mixed 1 to 3 products together and 4.9% mixed 3 products in one tank. When mixing pesticides, the majority of farmers do not respect the prescribed dose because of the lack of suitable graduate instrument. Only 3.7% of interviewed disposed and used full PPE during pesticide spraying against 89.9% of them who used partial PPE. Regarding how to dispose empty containers, 89.65% of farmers destroyed them by incineration against 11.2% who discard them in nature. These results indicated the unawareness of farmers about the hazard linked to pesticide use. For that, it is important to implement measures to support and raise farmer's awareness.

*Key words:* Apple tree, awareness, pest management, pesticide use, protective equipment

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Pesticides play a crucial role in agriculture by serving as essential inputs for safeguarding seeds and protecting crops against unwanted plants, insects,

bacteria, fungi, and rodents (FAO 2023). In the world, about 1.8 billion people survive on agriculture and use pesticides to manage insect pests and diseases to ensure healthy crops and food security (Grubeet al. 2011). Presently, controlling pests, diseases, and weeds that compete with culture was realized using synthetic and naturally occurring chemicals. Worldwide, the number of used chemicals as pesticides

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was evaluated to 1500 active ingredients (Bolognesi and Merlo 2011). In Tunisia, a wide range of pesticides are used throughout, especially in agriculture. About, 516 commercial names of pesticides are registered on different crops and distributed as follow: 174 insecticides, 205 fungicides, 92 herbicides, 7 nematocides, 6 rodenticides and 32 various (molluscicides, insect growth regulators, plant growth regulators, synergists, etc.) (Ministère de l'agriculture, de la Pêche et des Ressources Hydrauliques 2019).

In the past, pesticide employment by farmers held a significant position in the production system aiming to increase global agricultural productivity by protecting crops against different pests, diseases and weeds. Consequently, pesticides constituted one of the main components of modern farming, playing a crucial role in sustaining high production level (Tilman et al. 2002).

However, pesticides are considered as poisons that if used improperly or without knowledge of their side-effects can endanger human health and cause serious problems to environment. Furthermore, real hazard linked to human and wildlife was the results of persistent pesticide residues that can accumulate in the food chain and cause the contamination of the environment (Fabro and Varca 2012).

In developing countries, several research studies interested in the subject of pesticides use by farmers mentioned that the misused of these chemicals was linked to the lack of level of education and training in pesticide use, the acknowledge and insufficient information of other alternatives to pesticides and to their related hazards, the unwillingness of crop loss risks acceptance by farmers and the low cost of pesticides (Al Zadjali et al. 2013; Khan et al. 2015). The direct use of pesticides in these countries may be a

direct effect of the absence or the weak enforcement of laws and regulation, national policies related to pesticide use, also another factor in relation with local retailers who play the role of vulgarization agents and sometimes the promotion offered by agrochemical companies (Marcoux and Urpelainen 2011; Shreinemachers and Tipraqsa 2012)

In Tunisia, numerous studies have focused on pesticide residues and the risks they pose to consumer health (Bouagga and Chaabane 2015; Bouagga et al. 2019; Farhat et al. 2016; Mechichi et al. 2023) but, few scientific studies have delved into the realm of farmers' knowledge and utilization of pesticides in the field as the work made by Jeder et al. (2018) about the perception of pesticide risk used by farmers under greenhouses in center-east of Tunisia. In order to develop a strategy for monitoring pesticides usage in different agriculture sector mainly fruit production, it will be necessary to conduct a survey of the pesticides being used by farmers in different crops. Therefore, this paper represents the first scientific study in this field in center-west of Tunisia and has for objectives to evaluate the current status of pesticide use and to assess apple growers' knowledge on safe pesticide handling in Foussana area.

## **MATERIALS AND METHODS**

### **Study area**

This study was carried out in the village of Foussana located about 24 km in the north eastern from Kasserine town in center-west of Tunisia (35°20'58'' North, 8°37'40'' East) (Fig. 1). Covering an area of 94,240 ha, Foussana is located at the foot of mount Bireno (1419 m above sea level) in a valley perpendicular to the Tunisian ridge and situated in the south of Tebessa mountain. According to Hchaichi (2017), its climate can be classified as (BSK) type dry and cold steppe climate (semi-arid) with an annual temperature of

15.2 to 18.5°C and an average annual rainfall 316 mm.

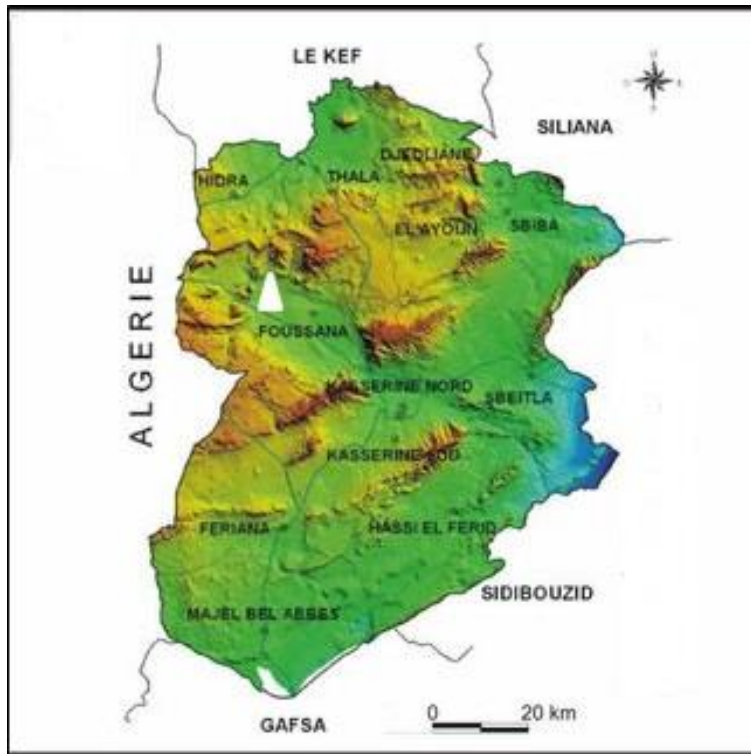


Fig. 1. Location of Kasserine governorate and the study zone Foussana (white triangle).

The survey was conducted at the end of the harvested season of 2018 between November 2018 and February 2019. The choice of the site of Foussana was done because it is characterized by an important agricultural activity mainly fruit tree growing and specifically apple tree crop (3,600 ha). It constitutes the second producing area of apple fruit in Tunisia with young plantations (< 20 years age). This speculation was conducted in intensive way which needs regular irrigation and important farm inputs,

particularly the use of chemicals as fertilizers and pesticides.

The survey was applied using a stratified sampling technique to a sample of 82 farmers. This sample size represents 5.61% of the total active population and to select farmers sample we adopt also a spatial strategy to reduce the time of survey.

Survey is based on a standardized questionnaire on pesticide management. It consisted in structured, semi-structured and unstructured items prepared using

published literature in the subject. Before starting the survey, a pre-tested phase was applied with a small sample of farmers in the area (not included in the study) to check how it easy understood by them and to measure the required time per farmer. This test helps us to improve the investigation questionnaire by adding the necessary amendments.

Data were gathered using the face-to-face individual interview with farmers which agreed to participate in this research study. Each individual was considered as a separate case and was interviewed in order to obtain information regarding socio-demographic characteristics, knowledge of pests and relative pesticides, sources of information about pesticides, mode and equipment for phytosanitary treatments, use of personal protection equipment (PPE) during and after pesticide treatments. These variables are clearly defined and labelled for data analysis.

#### **Data analysis.**

Computer data entry was done in Microsoft Excel and analysis was performed using Statistical Package for Social Sciences version 20 (IBM SPSS. 20). All data were subject to descriptive statistics (frequencies, percentages and means) to generate summaries and tables.

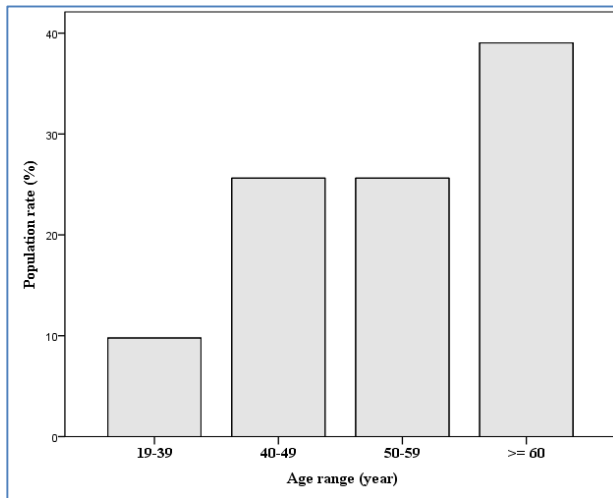
## **RESULTS**

### **Socio-demographic characteristics of farmers.**

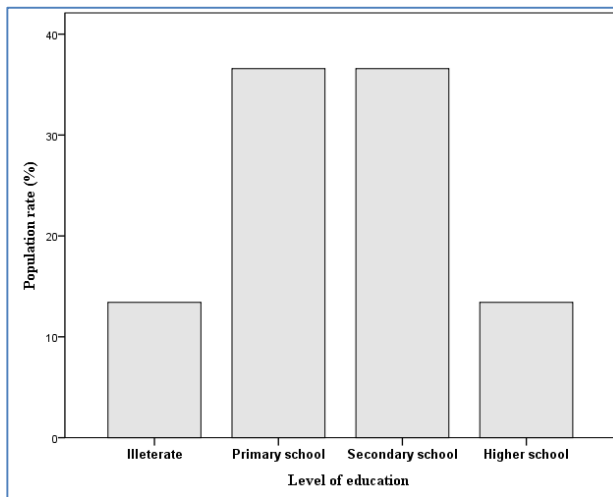
Analysis of gathered data reveals that the majority of farmers were male

(97.53%) with a mean age of  $54.16 \pm 11.83$  years ranging from 19 to 80 years. Fig. 2 shows that the majority of respondents (39%) were of the age group above 60 years followed equitably by the two groups age 40-50 and 50-60 years with 25.93% for each one. However, young farmers which age ranged from 19 to 40 years, represents the smallest percentage with only 9.87%. Consequently, apple sector in Foussana was dominated by old and ageing experimented farmers (> 50 years) which provide a weak hope to educate new and safer pest management techniques in the future. The influence of these socio-demographic characteristics will appear on the behavior of farmers during the next steps of this study.

Regarding educational level (Fig. 3), illiterate farmers, with no formal education, account 13.58% of the study population. About 86.42% of the interviewees had formal education. From this percentage, 35.8% of farmers have a primary level education i.e., not more than 6 years class education and could be considered as semi-illiterates with poor reading skills. For the rest half of population, 37.04% have a secondary education and 13.58% with a university education. These data about educational level permit to conclude that likelihood they will read and understand the pesticide label. Meanwhile, farmers with lower-level education can face some problems to perform certain details related to operational habits and hazards in relation with chemical application.



**Fig. 2.** Distribution of interviewed farmers by age range.



**Fig. 3.** Education level of farmers in Foussana delegation.

All interviewed farmers in the study area are the own owners of their land and are apple growers in intensive system. Among the surveyed farmers, about 47.6% had 5 to 10 year experience in the field, 44% between 10 and 20 years and 4.9% more than 20 years of experience. The mean years of apple farming was evaluated to 12.44 years. More than 84%

of the studied samples were originally apple producers and considered apple orchards as their primary financial source, the rest 16% had another occupation and considered agricultural as a second financial source. This analysis revealed that apple growers in this area have adequate experience in the field and a good

knowledge about intrants (fertilizers, pesticides, etc.).

### **Current pest management practices.**

Orchards of apple were subject to attack by various bioaggressors belonging to different groups: insects, mites, rodents, birds, fungi, weeds and others. The most destructive were insects, mites and fungi, especially when they were not controlled. Yield reduction of apple fruit constitutes the direct impact of pests and diseases both on quality and quantity.

Knowledge of apple growers on apple pests is limited to the major destructive ones; codling moth in first place followed by the red mite specie *Panonychus ulmi* and one to two aphids. This little knowledge on pests may be the result of new unexperimented land owners in the area following the extension of new plantations, low transmission of technical information between generations, independency of farmers in conducting their orchards resulting from a lack of contact with extension agents, there is also a lack of exchange of scientific information between researchers, extension agents and farmers, even climatic changes which lead to the emergence of new unknown pests.

All apple growers are highly dependent on pesticides to control pests in their orchards and no other alternative method was used in the area of study. Two types of practices of pesticides were applied by apple growers in the area of Foussana, prophylactic and curative treatments. It is also important to mention that they did not have any idea about the notion of harmfulness threshold.

Prophylactic treatments were applied against codling moth and mainly fungal diseases (scab and powdery mildew). The recourse to such treatment was the result of several factors as the lack of scientific information and knowledge

about the biology and the harmfulness threshold of pest, the non-regular control/survey of orchards during the period of risks and old practices learned from old farmers. These prophylactic sprays applied before the appearance of pests in the field increased the load on the orchard by unnecessary expenses add to the rising of risks of environmental pollution by the overuses of pesticides.

Curative sprays were applied against aphids and mites after the detection of these pests in the field. In this case, the harmfulness threshold was also ignored because farmers initiate treatments directly after pest detection.

The most destructive pest in apple orchard was the codling moth (*Cydia pomonella*). It causes direct damage in fruits and can eradicate all the production in case of non-intervention. For this reason, farmers fight it intensively with a treatment every 7-10 days without considering the product persistence time in the field. In this case, 12 to 16 treatments were applied against this moth per season between mid-May and August.

### **Knowledge and sources of information on pesticide use.**

To protect and secure their production and orchards, all apple growers in the area highly depend on the use of pesticides to control pests and diseases. The use of pesticides by apples growers of Foussana delegation is relative to their experience in this field and almost to the age of their plantation. Basing on collected data, 51.2% of farmers have less than 10 years of experience with pesticides and 48.8% have used these products for more than 10 years. This finding revealed the importance of extended area during the last decade. It is also important to mention that all interviewed population, independently from age and education level, were aware about the danger

associated to pesticides on human health and environment safety.

Interviewees were asked firstly if they know the commercial name of pesticides they used in their farms. If the answer was “No”, the second asked question was who suggest them names of products i.e., which were their sources of information?

Three exterior sources of information about pesticides which were available to farmers in Foussana delegation are extension service of the local agricultural authority, pesticide retailers and neighboring farmers. Data analysis (Fig. 4) revealed that 86.6% of apple growers answer knowing the used pesticides within their farms. Despite this important percentage, they still need exterior supervision about these products. In fact, the assessment results showed that 97.6% of interviewees needed supervision to buy chemicals. The majority of farmers (70.7%) declared that they are assisted on

the choice of pesticides solely by extension services of the local agricultural authority against only 4.9% who consider pesticide retailers as principal source of information. A part of the first category of farmers who received information from agents of extension service communicates it to other farmers. About 15.9% of respondents relied on information provided by the twice previous sources at the same time. In this case, farmers were firstly assisted by agents of extension service then re-assisted or reoriented by retailers when buying products. Apple growers rely also on their proper experience (4.8%) and on information delivered from other neighboring farmers (3.7%). Consequently, 96.3% of interviewees do not communicate together to help each other and to exchange their experience, this may be for social or economic reasons, which made hardly and difficult the spread of information by oral communication between them.

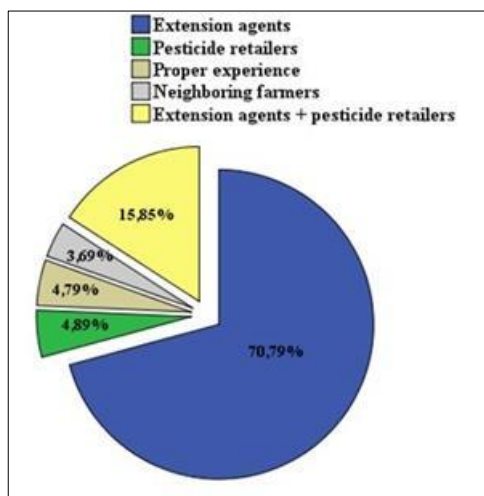


Fig. 4. Source of information about pest control and pesticides.

However, farmers dealing directly with pesticide retailers indicates their dependency on retailers' advices and behavior by buying products from them on credit and reimbursing them at the end of the season after the harvest, while farmers who rely on their proper experience have mainly higher education level or the terminal classes of secondary school and have access to technical documents and internet.

### **Availability of pesticides and sources of supply.**

Yield losses in apple orchards in center-west of Tunisia are mainly caused by insect pests and in less level by fungal diseases and mites. All farmers reported their dependency on pesticides to ensure apple production.

Inventory of different pesticide formulation listed by farmers during survey in the study area show three use types of formulation whose most of them (47.76%) were insecticides followed by fungicides (28.36%) and acaricides (23.88%). There is no use of other chemicals like herbicides, rodenticides, nematicides, etc. Data analysis of phytosanitary products in the study area reveals a total of 59 different commercial names of pesticides used in apple orchards of Foussana which were distributed as follow: 28 insecticides (47.46%), 18 fungicides (30.51%) and 13 acaricides (22.03%). A total of 35 active ingredients were used by apple growers to control pests. Concerning insecticides, 15 active ingredients belonging to 10 chemical families were applied such as pyrethroids (including deltamethrin and lambda-cyhalothrin, alphas-methrin and cypermethrin), organophosphates (chlorpyrifos and dimethoate) and carbamates represented by methomyl which was used twice a time per season by all farmers to

control red ants during the blossoming period.

Insecticides were the most applied pesticides because insects represented the most serious problem in apple orchards of Foussana, characterized by its continental climate. Insects were also active during the holly season contrarily to mites and fungal diseases whose presence were conditioned by specific conditions, like hot temperatures and humidity. Herbicides were never used by farmers for the simple reason that they proceed to mechanical or manual weeding by deploying community members.

Table 1 summarized the active ingredients of used pesticides and their classification using the WHO hazard class of 2019. The most popular active ingredients were deltamethrin (21.3%) as component of insecticides and abamectin (9.8%) as acaricide. Among the thirty-five active ingredients identified in our study, two products (5.71%) were classified as highly hazardous (Ib) according to the WHO classification (abamectin against red mites and methomyl as insecticide), 42.86% belonging to Class II were registered as moderately hazardous, 34.89% slightly hazardous (Class III) and 17.14% are unlikely to present acute hazard (Class U).

Sources of pesticide supply based on the collected data reveal that 96.3% of apple growers in the region buy their phytosanitary products from local retailers installed in the village of Foussana. In this case, they were faced to a less diversified range of active ingredients and commercial name products conditioned by retailers. However, farmers owning large area (2.4%) travelled 30 to 50 km out of the village to other agglomerations using their own means of transport to buy their products from wholesale distributors.



**Table 1.** Traits of active ingredients by farmers

Active ingredient	WHO Class	Target pest	Family	Use (%)
<b>Insecticides</b>				
Acetamiprid	II	Aphids	Neonicotinoids	0.5
Alphamethrin	II	Codling moth	Synthetic pyrethroids	9.8
Cypermethrin	II	Aphids	Synthetic pyrethroids	2.6
Chlorantraniprol	U	Codling moth	Anthranilicdiamids	0.3
Chlorpyrifos-ethyl	II	San jose scale, leafhopper	Organophosphates	8.5
Deltamethrin	II	Codling moth, Aphids	Synthetic pyrethroids	21.3
Dimethoate	II	Codling moth, Aphids	Organophosphates	4.1
Flufenoxuron	III	Mites, codling moth	Benzoyleureas	0.3
Flupyradifuron	II	Aphids, leafhopper	Butenolides	0.5
Imidacloprid	II	Aphids	Neonicotinoids	8.7
Lambda cyhalothrin	III	Codling moth, Aphids	Pyrethroids	3.9
Spirotetramat	III	San jose scale	Ketoenols	1.3
Teflubenzuron	U	Codling moth	Benzhydrazids	0.3
Thiacloprid	II	Codling moth, Aphids	Chloronicotinils	10.1
Methomyl	Ib	Red ants	Carbamats	-
<b>Acaricides</b>				
Abamectin	Ib	Mites	Avermectins	9.3
Chlorpyrifosethyl	II	Mites, San josescale	Organophosphates	8.5
Clofentezin	II	Mites	Tetrazins	2.6
Flufenuxeron	III	Mites	Benzoyleureas	0.3
Soufre	III	Mites, oidium	Mineral products	0.5
Spirodiclofen	III	Mites	Ketoenols	6.2
Spiromesifen	III	Mites	Ketoenols	4.1
Tebuconpyrad	II	Mites	Carboxamidpyrazols	5.1
<b>Fungicides</b>				
Bromuconazole		Powdery mildew (PM)	Triazols	
Bupirimate	II	PM	Pyrimidins	
Carbandazim	III	PM, Apple Scab (AS)	Benzimidazols	
Cuivre metal	III	AS	Mineral products	
Difenoconazole	III	PM, AS	Triazols	
Fluopyram	II	PM, AS		
Fosetyl Al	III		Phosphonats	
Mancozebe	U	AS	Dithicarbamats	
Mefenoxam	U		Phtalimids	
Pyrimethanil	III	AS	Anilinopyrimidins	
Soufre	III	PM, AS	Mineral products	
Tebuconazole	III		Triazoles	
Thiophanate methyl	II	PM, AS	Benzimidazols	
Triadimenol	U	PM	Triazols	
Trifloxystorbin	II	PM, AS	Strobilurins	
	U			

Ia = Extremely hazardous; Ib = highly hazardous; II = moderately hazardous; III = slightly hazardous, U = unlikely to present acute hazard in normal use

Regarding the mode of supply of pesticides, three categories of farmers were distinguished. The first dominant category represents 95.1% of the study population who bought their products in detail. In this category, farmers either carry out a diagnostic work within their orchards to determine existing pests or

asked their fellow farmers (neighbors) before buying just the needed amount of products one to two days before its application. During this short period, bought pesticides were kept inside a room with fertilizers and farm implements until their use. While the second category with 3.7% of farmers buy their products in bulk

and store them in a multipurpose room reserved for inputs with fertilizers and farm working tools. These farmers who have generally important area use their proper experience and the data of previous campaign to estimate the inputs of the next campaign. The last category of farmers bought pesticides sometimes in details and sometimes in bulk represent 1.2% of the studied population.

### **Farmers reading and understanding the label of pesticides**

Pesticide label represent the identity of used products. It contains all necessary information (product name, class designation, ingredients, registration number, etc.) and a guide to help applicators during all the process of its preparation. It constitutes also a source providing all necessary information for safe use of the pesticide to avoid risk to human health and environment safety.

In order to assess whether farmers pay attention to the instructions described on the pesticide labels, they were asked if they read the instructions on the product labels or not. If the answer was “no” we asked them what is the reason to not doing this. If the answer was “yes” we questioned them which label part they read and their ability to understand what they read.

The present study reveals that 35.71% of interviewees did not read at all the written instructions on pesticides containers or bottles. This category of farmers which most of them are illiterate or have very low level of education receives information about pesticides from two sources either local retailers or neighboring farmers. The second category of farmers are dominant, representing 38.68%, declare they sometimes read and sometimes not the label. From all instructions on the label, the reading was only limited to the uses doses without

paying attention to other instructions on compatibility with other products and the safety of its use. When asked about the reasons of not reading all the label, 62.86% answered that it was written in too small font making it difficult to read and 37.14% said in addition to the previous cited reason that they already have the basic knowledge on the use of pesticides and that the label was sometimes so technical and written in foreign language.

However, 25.61% of farmers report reading always the label of used products. When questioned if they read the entire label, all of them answered that they use pesticides for a long time and their interest was focuses on the used dose (cc/hl or g/hl) and compatibility with other types of pesticides. When asked, when the instructions were written in too small font, do they even read the label? The majority answered, it took more time but they do it.

In conclusion of this part, with the absence of reading, understanding and observing the instructions mentioned on the product labels, farmers will undoubtedly be confronted to the risks of pesticides. Generally, product labels written in technical terms were oriented to technicians and certified persons with a certain level of knowledge in the field.

### **Pesticides from preparation to application**

In the study area, farmers ensure themselves all steps related to pesticides: preparation, mixing, loading and application. All these operations occurred mostly manually near the water source within the orchard. Farmers who mix chemicals using gloves to protect themselves accounted for 51.32%, while the rest 48.68% did not apply this measure of protection because of lack of the necessary equipment for this action.

Farmers did not dispose of suitable material (graduate instrument) to

measure the exact dose of product to put in tank. Most of them declare not respecting the prescribed dose and can sometimes double it when mixing in the goal to increase the efficiency of used product. For this operation, farmers often use pesticide packaging, which were sometimes 50 to 100 ml graduate depending on its volume, to measure the prescribed dose to put in tank, but this method was not so reliable because the scale was not graduated. This behavior can be explained by the rupture of communication between the entire circle of stakeholders in this field grouping from the upstream to downstream scientists (academic from universities and researchers), policy makers, extension agents and farmers. The last element constituting the main profiteer feels abandoned to themselves and as a result they try to find solution using their proper philosophy and experience. They experiment pesticides using their own dosage.

Pesticide application is performed using either trailed hydraulic atomizers (20.7%) or standard trailed sprayer (79.3%) with tank capacity of 400 liter in major cases. Pesticide application differs from one farmer to another especially regarding the variable number of mixed products per tank of treatment. For the study population, about 42.7% of farmers did not mix pesticides and used only one product per tank during all the season. Most of these farmers have their own materials of treatment and apply products to target detected pest. Other farmers (31.7%) apply always two products per tank; used combinations depend on the period of pest apparition and are formed mainly by insecticide-fungicide and rarely by insecticide-acaricide or fungicide-acaricide combinations. A third category of farmers treats sometimes using 1 or 3 pesticides;

they represent 20.7% of the study population. About 4.9% putted a maximum 3 products together in a single tank. When asked how they choose products when mixing, they reply doing it randomly according to the existing pests in field and without receiving any specific instructions either from the technical staff or when reading label. Farmers applying mixture reveals they do this for two reasons, serving time by decreasing the hours of work since several pesticides were applied together in a single spray and for an economic reason by reducing cost as a result of reducing the number of passages of treatment equipment.

The spraying time is conditioned by the climatic conditions, which give rise to physical spraying losses, and by evaporation. The main considered parameters are temperature, wind direction and speed, and precipitation which can all affect the efficiency of the spray. Consequently, the choice of the intervention moment is decisive in the success of this action. Our data showed that almost three quarter of farmers (74.4%) choose the early morning to spray pesticides against 12.2% who prefer the night time. While other farmers treat their orchards sometimes in early morning and sometimes at night, and in this case, application time depends on the material availability. Only 2.4% of farmers apply pesticides in the morning and at night. These respondents are owners of important sizes which needs several days of work. They are also possessor of their proper spraying material; for this reason, they start treatment before sun rising and continue during all night until the morning, make a stop during the journey and restart at night. The last type of farmers who realize the pesticides treatments after the sunrise represent 1.2% of the study population. All farmers reported taking into consideration the factor wind, its

direction and speed before application and do this in the same direction to protect themselves against the inhalation of products.

### **Container disposal.**

After pesticide mixing, the rest of the product in the container if not rinsed carefully represents an average of 1 to 4% of its original content. Even it is negligible, this quantity still sufficient to represent a risk for people and the environment. Most farmers in Foussana typically rinse the container multiple times with water immediately after emptying it, and then pour the product into the tank for its intended purpose. In Tunisia, the management of phytosanitary waste remains inadequate, despite the establishment of the National Agency for Waste Management. These types of wastes are classified dangerous by the Decree No. 2000-2339 of October 10 (Salem et al. 2019). From the pesticide purchase until its use, the management of the packaging remains the responsibility of the user.

Proper disposal of empty packaging post-use emerged as a significant environmental and health-related concern for management. In the study area, the majority of farmers (87.65%) destroy empty containers by incineration or burial in a pit prepared for this purpose. It was notable that 1.23% of farmers recover mainly big container of 1 and 5 liter to reuse them for storing water and other liquid food like olive oil. However, 11.12% of visited subjects discard pesticide containers waste into the nature between rows of trees or near water point inside their orchards.

### **Use of Personal Protective Equipment (PPE).**

Although their awareness about the danger linked to used pesticides

farmers did not protect themselves properly at the moment of application. Results revealed that only 3.7% of apple farmers disposed and used full PPE in their orchards during pesticides application, while the majority of farmers (89.9%) used on partial or at least one form of PPE during spraying i.e., a combination of existing equipment and 7.3% apply pesticides without any protection. Farmers disposing of PPE were asked if they already have their own special Personal Protective Equipment (PPE)? 93.9% answered “Yes” and report using it, and the rest 6.1% answer “No” and never use these equipments. When this variable was crossed with age and education level of farmers, the frequencies analysis did not reveal any difference between the studied classes. This revealed that farmers were already aware of the danger linked to pesticide use. However, this knowledge does not seem to be sufficient enough to encourage them to more protect themselves by applying the appropriate protection procedures during and after handling pesticides.

The first part of Table 2 summarized all recorded habits exhibited by farmers during and after spraying. Farmers reported taking into consideration the wind direction and speed before running application and apply treatment in the same direction to protect themselves against the inhalation of products. Out of the total studied population, 98.8% were aware of the danger of eating and drinking during pesticide application, while 1.2% declared eating and drinking during the time when tank was recharged. They were encountered within orchards of high size when time of spraying was long. Preventive measures were also continued after work by washing hands, taking a shower and changing clothes.

**Table 2.** Prevention measures during and after pesticides application

Prevention measures	Farmers (%)
Avoid eating and drinking during application	98.8
Avoid smoking during application	100
Observe wind direction	100
Wash hands after work	100
Change clothes after work	100
Take a shower after application	100
Use dust mask	89
Use gloves	47.5
Use boots	67
Use apron	49.2
Use safety goggles	8.5
Use overalls	3.7

Used PPE cited by farmers were composed by one or more of next equipments: dust mask, gloves, boots, apron and safety goggles. Results in the second part of the Table 2 indicated that the most frequently used equipment was the dust mask (89%) to avoid inhalation of spray during treatment, followed by gloves (47.5%) and boots (67%). Those who used apron, safety goggles and complete equipment were rare (< 10%). When asked about different combinations of used equipments, 47.37% answered using gloves and dust mask, while 10.53% of farmers used gloves, apron and dust mask against 32.89% using gloves, boots, dust mask and a water proof overalls.

In the study area, farmers realized and controlled themselves all the steps of pesticide application (preparing, mixing, loading and applying). All farmers were ignorant about the order of mixing pesticides in the tank i.e., what they putted firstly liquid or powder product.

## DISCUSSION

This study showed that apple growers in Foussana delegation depend heavily on pesticides to control pests in their orchards. The high frequencies of pesticides use per cropping season are probably the result of several factors mainly the lack of appropriate knowledge

on the ecology of target pests, the notion of the economic threshold and the access to other alternatives to chemical control as biological control and IPM strategies. These facts conducted farmers to face pest problems by intensive application of different types of pesticides. Other features linked to awareness of farmers that harvest loss was the direct impact of pest attacks and the only way to secure their income resides on the indispensable use of pesticides. In this context Stadlinger et al. (2011) cited that smallholder rice farmers in Tanzania are aware and encouraged to overuse pesticides to secure high yields.

Farmers who declare being assisted by extension service revealed that in the majority of cases, it is themselves who move to the local agricultural authority office to ask for pesticide needed. In this case, there is no direct diagnostic of pest situation in field and farmers still constrained by the lack of suitable knowledge. Additionally, pesticide usage seems to be in part influenced by pesticide retailers who play the role of adviser to commercialize their products and to achieve maximum gain. This situation is encountered in many developing countries where vendors influenced the choice of pesticides to be used by farmers (De Snoo et. al.

1997; Epstein and Bassein 2003). Our results are totally different from those cited by Jallow et al. (2017), who reported that 26% of Kuwaiti farmers rely on their own experience when seeking knowledge of pest management and pesticides, 19% seek information on books, 50% from other farmers and 75% are dependent from pesticide retailers. This finding is consistent with the argument advanced by Ali et al. (2013) in which they reported that farmers with higher education level or training on pesticide application are not influenced by retailer suggestions add to the lower bought and used amount of pesticides. However, Lamosa et al. (2013) highlighted the significance and positive influence of farmers' education levels on pesticide handling for greenhouse farms in Galicia, Spain. According to these authors, pesticide applicators with higher qualifications that are often experienced applicators are either fully dedicated to agriculture or affiliated with cooperatives, or agricultural processing companies.

In the study area, insecticides were the most used because insect pests were the most serious problem in apple production due to the continental climate. This was followed by fungicides and acaricides use. Farmers overused pesticides because of the lack of update information on pest ecology, add to the use of an ancient calendar/program established by the extension service of the region in collaboration with an American project in 1995 to spray pesticides, mainly against codling moth, without paying attention to the existence or not of the target pest. This high frequency use of pesticides leads to their frequent contact with these products and then to a possible significant health problems. Gupta (1994) mentioned that a continuous exposure even of a short duration to pesticides will have cumulative delayed effects over years.

All the pesticide active ingredients are currently registered for use in Tunisian Phytosanitary Guide of 2019. Among the 35 pesticide active ingredients identified in our study and according to the WHO classification, two were classified as highly hazardous, one insecticide (methomyl) and one acaricide (abamectin), and the rest was classified as moderately (Class II) and slightly hazardous (Class III), and may present risks to environment safety and human health if they are not properly used. Our finding is in concordance with Atreya et al. (2012) working in Nepal.

The first steps of preparation of pesticides observed in this study indicated that farmers lack basic knowledge of pesticides. They ignore/do not respect the order of mixture of pesticides based in their formulation (WP, EC, SC, GS, etc.).

Generally, the frequencies of pesticide application by farmers were high. This can be explained by the preventive treatment applied every 10 to 15 days since early May to late August, mainly against insects and specially the codling moth (*Cydia pomonella*), compared to curative application requiring the detection of pests. This overuse of pesticides can be due probably to the lack of scientific results about the ecology, the period of flight and the number of generations of this pest per cropping season in the region. All these key parameters need the availability of specific pheromones to ensure a good survey to obtain reliable scientific results. Add to this, frequent contact with these products can affect significantly the health of farmers and the safety of the environment.

Our finding does not concord with the study of Sharafi et al. (2018) made in agriculture land of Kermanshah in Iran; they reported that over 61% of farmers are autonomous when using pesticides and 32.8% of them followed instructions.

These farmers used incorrect and high-risk methods for pesticides manipulation and container disposal as a result of incorrect knowledge about pesticides and the management of their risk. Concerning PPE, in this same study, authors cited that 18% of interviewed farmers used full body protection (hand and face) during spraying which reveal more awareness than our apple growers (3.7%) against more than 13% who applied pesticide without any protection.

Rijal et al. (2018) reported that about 34% of vegetable growers in Chitwan, Nepal, read pesticide instructions before its application, 56% understand it and 31% of them had little knowledge about the mode of action but although these positive points, Mainali et al. (2010) reported that farmers lacked knowledge on the safe use of these products.

The majority of farmers who used partial PPE are not well protected against pesticide and were exposed to the risk of contamination. These findings agree with Jedder et al. (2018), who reported that nearly 63% of farmers in center-east of Tunisia, producing vegetables within greenhouses, do not wear appropriate protective equipment during pesticide application. Farmers in Chitwan, Nepal, and despite their low knowledge on pesticide label, 86% of them protected themselves using a form of personal protective equipment. From this percentage, 34% of farmers have access to mask and 52% used facemask and other equipment as gloves, shoes, long sleeve clothes or a total protection (Rijal et al. 2018). The same authors reported that 14% of farmers do not use any form of protection when handling pesticides. This behavior is also observed in other developing countries. Enserink et al. (2013) mentioned that, in contrary, farmers do not reduce but still abuse

pesticides to ensure higher crop yield although their awareness about their risks and dangers to human and environment.

The high dependence of apple growers on pesticides is an important indicator that they have limited or no knowledge on other management methods to control pests that can be effective, reasonable, economical and friendly to the environment. It is important to learn them about the existence of other benefit organisms and their potential role in the nature as pollinators and natural enemies (predators and parasitoids) that are negatively affected by pesticide spraying.

Matthews (2008) advanced three basic principles as the good practices for self-protection from pesticides: the right method of application, the use of adequate PPE during spraying and the personal hygiene. The use of right PPE reduces greatly the risk of poisoning of farmers by sprayers and this risk can be reduced by about 44% as published by Dasguspta et al. (2007). However, the results of applying pesticides without any protection endangered significantly the health of farmers (Yang et al. 2014).

Management of empty packaging after use was also an important issue of environmental and health concern as described by Salameh et al. (2004). These practices have been also reported by Matthews et al. (2003) in Cameroon. A study conducted in a farming area in Nepal reported that 60% of farmers destroy or buried pesticide container after use, 13% kept them in a safe place, 22% vended these containers to recycling companies and 5% throw them in the nature (Rijal et al. 2018). Another study conducted in China reported that farmers threwed the remaining pesticides into public lands and water sources (Yang et al. 2014).

The current study represents a diagnosis of the current state of the use of pesticides and the practices adopted by

apple growers in Foussana, in order to evaluate how they handle pesticides and to identify the factors that affected these practices. It was observed in Foussana region that there is no way to growing apple without applying pesticides. All apple growers used frequently these chemicals to manage all types of pests in their orchards.

In this study, pesticide retailers play important role as technical advisors for a part of farmers. So, it will be very important to provide them specific extension training and to deliver them a certification as an authorization to practice this job. Such training can help local retailers to improve their knowledge about pesticides and their safe use as well as to deliver correct and valuable information to farmers by improving communication with them.

Labels instructions written frequently in foreign language using technical terms and in small fonts discourage even the more educated farmers to read them and in case when they do this it leads to a misunderstanding of its content/message and then to inappropriate use of the product.

Even they declare their awareness about risks associated to pesticides, the majority of farmers is still not so aware about their real danger; this was confirmed by partial use of PPE leading to the direct exposition of their body to pesticides. This behavior can affect negatively their health as well as the overuse of products which can be hazardous to environment. In this context, special extension training for farmers needs to be conducted periodically, every three years, to learn them about the safe use of pesticides regarding to themselves, the consumer and environment respect. Also, they can be informed about the

importance of individual protection during the spraying operation, the respect of subscribed dose, label reading, etc. Government can help to support such program by supporting the availability of PPE at low costs.

The management of packaging still remains a challenge in the marketing of pesticides because users are not sufficiently aware of the techniques for managing empty packaging. Regulations should be applied to importing distributors for the recovery of empty vials with a view to their destruction or controlled incineration in accordance with recent FAO recommendations (FAO 2023).

In a mainly future perspective, it will be very important to work on the reduction of pesticide dependence and to reinforce pest management by other alternative strategies including biological control, cultural methods, IPM, etc. Thus, farmers need extension training on all packages of pesticides. The most noticeable points to educate them should be focused on: (a) detection and identification of pests in the field, (b) choosing appropriate pesticide for identified organism, (c) how to read instructions written on the label, (d) basic steps of mixing pesticides, e) knowledge of the economic threshold to determine the right timing of spraying, (f) container disposal and use of PPE. This would provide farmers significant health, economic and environmental benefits.

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## RESUME

**Soltani R. 2024. Evaluation des connaissances et de l'utilisation des pesticides par les pomiculteurs de la délégation de Foussana, gouvernorat de Kasserine, au centre-ouest de la Tunisie. Tunisian Journal of Plant Protection 19 (1): 43-62.**

Les pomiculteurs au centre-ouest de la Tunisie sont fortement dépendants des pesticides pour assurer la protection phytosanitaire de leurs vergers. La présente étude a été menée auprès des pomiculteurs de la délégation de Foussana à l'aide d'entretiens en face-à-face pour déterminer les caractéristiques sociodémographiques, l'état de la lutte contre les nuisibles, leur niveau de connaissance de la manipulation des pesticides, leur capacité à comprendre les consignes sur les étiquettes des produits et l'utilisation des équipements de protection individuelle (EPI). Les résultats ont montré que les agriculteurs utilisent 3 types de pesticides dans leurs vergers: des insecticides (47.76 %), des fongicides (28.36 %) et des acaricides (23.88 %) parmi lesquels 96.3% sont achetés auprès des détaillants locaux. Environ 25.61% ont déclaré lire toujours les étiquettes des pesticides avant leur application contre 35.71% ne les lisant pas du tout et 38.62% indifférents. L'ensemble des agriculteurs qui appliquent des pesticides en mélange représentent 57.3% de la population étudiée. Parmi cette population, 31.7 % mélangent 2 pesticides, 20.7 % mélangent 1 à 3 produits ensemble et 4.9 % mélangent 3 produits dans une cuve. Lors du mélange des pesticides, la majorité des agriculteurs ne respectent pas la dose prescrite faute d'instrument gradué adapté. Seulement 3.7 % des agriculteurs interrogés disposaient et utilisaient un EPI complet lors de la pulvérisation des pesticides contre 89.9% qui utilisaient des EPI partiels. Ces résultats témoignent de la sous-estimation des agriculteurs des dangers liés à l'utilisation des pesticides. Concernant l'élimination des contenants vides, 89.65% des agriculteurs les détruisent par incinération contre 11.2% qui les jettent dans la nature. Ces résultats témoignent de la méconnaissance des agriculteurs quant au danger lié à l'utilisation des pesticides. Pour cela, il est important de mettre en place des mesures d'accompagnement et de sensibilisation des agriculteurs.

**Mots clé:** Equipement de protection, lutte antiparasitaire, pommier, sensibilisation, utilisation des pesticides

## ملخص

**سلطاني، رسمي. 2024. تقييم المعرفة بالمبيدات واستخدامها من قبل مزارعي التفاح في معتمدية فوسانة، ولاية القصرين، في الوسط الغربي لتونس. Tunisian Journal of Plant Protection 19 (1): 43-62.**

يعتمد مزارعو التفاح في الوسط الغرب بتونس بشكل كبير على المبيدات لضمان حماية بساتينهم. تم إجراء هذه الدراسة بين مزارعي التفاح في معتمدية فوسانة باستخدام المقابلات وجهاً لوجه لتحديد الخصائص الاجتماعية والديموغرافية، وحالة إدارة الآفات، ومستويات معرفتهم بالتعامل مع المبيدات، وقدرتهم على فهم التعليمات المعروضة على ملصقات المنتجات واستخدام معدات الحماية الشخصية. أظهرت النتائج استخدام ثلاثة أنواع من المبيدات من قبل المزارعين في بساتينهم: المبيدات الحشرية (47.76%)، المبيدات الفطرية (28.36%)، والمبيدات الأكاروسية (23.88%)، منها 96.3% يتم شراؤها من تجار التجزئة المحليين. وصرّح حوالي 25.61% من المزارعين أنهم يقرؤون دائماً ملصقات المبيدات قبل الاستخدام مقابل 35.71% لا يقرؤونها على الإطلاق و 38.62% غير مباليين. حوالي 57.3% من المزارعين الذين تمت مقابلتهم يقومون بمزج المبيدات مع بعضها في نفس الخزان، منهم 31.7% يقومون بخلط مبيدتين اثنتين، 20.7% يمزجون من 1 إلى 3 منتجات معاً و 4.9% يخلطون 3 منتجات في خزان واحد. عند عملية مزج المبيدات، غالبية المزارعين لا يلتزمون بالجرعة الموصوفة بسبب عدم وجود أداة القياس المناسبة. حوالي 3.7% فقط من المزارعين يملكون ويستخدمون معدات الوقاية الشخصية الكاملة أثناء عملية رش المبيدات مقابل 89.9% منهم يستخدمون معدات الوقاية الشخصية بصفة جزئية. وتشير هذه النتائج إلى عدم وعي المزارعين بمخاطر استخدام المبيدات. أما فيما يتعلق بالتخلص من الحاويات الفارغة فإن نسبة 89.65% من المزارعين يقومون بإتلافها عن طريق الحرق مقابل 11.2% يقومون برميها في الطبيعة. تبين هذه النتائج عدم وعي المزارعين بمخاطر استخدام المبيدات. ولذلك، من المهم تنفيذ تدابير لدعم ورفع وعي المزارعين.

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