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ARAŞTIRMA MAKALESİ **RESEARCH ARTICLE**

The Study of Post-Harvest Cereal Practices and Socio-Economic Impacts of Chemicals Used For Grain Storage In Morocco

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Abstract

This study was conducted to characterize farmers' post-harvest conservation practices and identify the different storage structures, the main pests of cereals in stock, as well as the mode of application of insecticides to protect seeds against pests infestations. To identify these practices, we have prepared a questionnaire answering the main characteristics of the population of the three provinces. The grain storage structures in our region vary depending on the locality and the quantity of seeds stored. These structures play an essential role in grain conservation in reducing post-harvest losses. There are several traditional techniques for storing cereals, such as traditional granaries, which represent most used structure by respondents (59.46%). Unfortunately, 40% of farmers surveyed say they sell their crops because of the financial pressure is the fear of damage during storage. The main pests responsible for losses are seed weevils (*Sitophilus granarius*), tribolium (*Tribolium castaneum* (Herbst) or *Tribolium confusum*), and cereal alucites (*Sitotroga cerealella*) with a percentage of 72%, 22%, and 6% respectively. However, the use of synthetic insecticides continues to be the major solution used for seed protection. However, our results revealed that the use, the doses, and the precautions of use of these insecticides are not respected, only 20% of the people surveyed know that there is a possibility a risk of intoxication by insecticides. The study shows that respondents are mishandling and overusing insecticides to protect cereals from pest infestations. This information is essential to recognize the origin of food poisoning among consumers and the worrying health risks humans.

Keywords: Conservation, Cereal, Post-harvest, Insecticides, Health risks

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1. Introduction

Grains are essential components of human food. They are especially interesting for their energy supply, like proteins, calories, vitamins, and dietary fiber. They are also a source of food for poultry and cattle.

The cultivation of cereals is done once a year, while its consumption is intended throughout the year. Due to the Mediterranean climate, this crop is subjected to climatic constraints and hazards such as irregular rainfall and drought. To ensure food security and self-sufficiency, especially with the country's population growth, the storage of this food is necessary. Nevertheless, during storage, these foodstuffs can be damaged by several aggressors and annual losses have been recorded. In developing countries, post-harvest cereal losses are more severe than those in developed countries; in Africa post-harvest losses from harvest to market are around 10 to 20% (Boateng, 2016). Other researchers have reported losses of over 50% in cereals and up to 100% in legumes (Obeng-Ofori, 2011). Because of the stagnation of cereal consumption during the year, the storage of the latter has many problems, the most important of which are insects that are perceived at the level of the producer as losses meaning that they subsequently reduce the weight of the commodity in case of heavy infestation (Gueye et al., 2012). Yet, beetles are the largest group within the insect pests of stocks (Adjalian et al., 2014). In the fight against these parasites, the farmers in Morocco systematically use synthetic chemicals to preserve the quality of their stored products. However, many insecticides have been banned in recent years because of their persistence in the environment. There are several issues, namely are insect resistance, food contamination by pesticides, environmental pollution issues, disruption of natural balance, toxicity to non-target organisms, the largest negative impact on human health (Grdiša and Gršić, 2013). Nevertheless, cereals treated with insecticides can contaminate the circuits, so cross-contamination of grain by handling and storage equipment can lead to marketing and compliance issues (Dauguet et al., 2006).

The objective of this study is to determine, using a questionnaire, the cultural practices for the conservation of cereals, in particular wheat and barley, and to describe the mode of application of synthetic insecticides against the main pests of cereals and identify the constraints of the people surveyed to preserve the quality of stored seeds.

2. Materials and Methods

2.1. Area and population studied

Our study area is located in the northwestern part of Morocco. This area occupies a special place at the national level as a producer of cereals. It is composed of three provinces: Kenitra, Sidi Kacem, and Sidi Slimane. The overall sample was randomized. It consists of 300 people divided into subgroups of 100 people per province, meeting the main characteristics of the population to have a better representation.

2.2. Data Collection

In our study, cereals farming occupies a large agricultural region. We are interested in the resorts that harvest fall cereals. We have reinstated a survey that has been translated to the local language of the villagers and the questions are orally presented. It is a set of questions linked in a structured way to obtain the maximum amount of information. We obtained the final development of this questionnaire after modification and improvement as it was used during preliminary surveys. It covered general information (date, location, occupation, etc.)-specific issues such as storage characteristics, infrastructure, and the different pests of stored seeds, then direct observations on some sites to witness how diverse structures and storage methods looked in real life.

3. Results and Discussion

3.1. Different places of purchase of seeds

The analysis of sales by species shows that soft wheat ranks first at 60.43%, followed by durum wheat at 36.05%, and barley at 3.52%. The use of certified seed of SONACOS (National seed marketing company, Morocco) by most farmers (57.2%) is the most effective way of ensuring high qualitative and quantitative value, which contributes significantly to the increased productivity *(Figure 1).* For this reason, the areas, production, and marketing of certified seeds are evaluated. However, small farmers prefer to buy their seeds from the local market

(29.96%) or other places of purchase when it comes to small areas. In Thrace, the most important criteria for farmers for wheat seeds selection are experience and advice, high quality and price, suitability for climatic conditions, support purchases, and low production costs, respectively (Keleş, 2019).

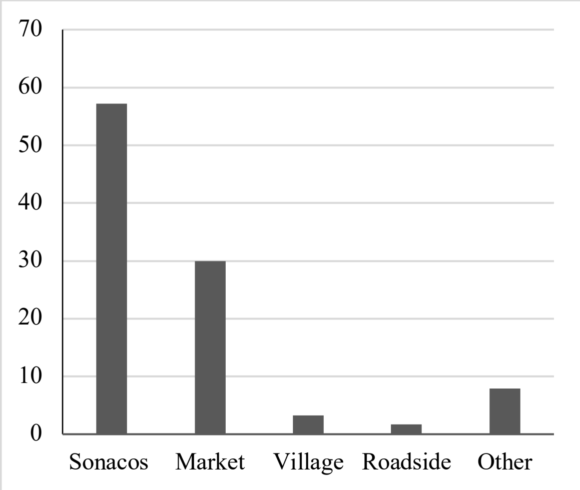

Figure 1. Type of places of purchase of seeds

3.2. Destination of seeds harvested

Once the seeds have been treated with chemicals, they are planned either for storage or for direct sale. Farmers market their post-harvest cereal crops to traders who buy them and store them for transport to the market for sale at a higher price. The three crops with the highest harvests were recorded during the survey, namely, common wheat, maize, and durum wheat. However, the obligation of early sale shortly after harvest misses the opportunity to increase the income of crops harvested by farmers. The results of the survey showed that 40% of farmers surveyed sell their crops because of financial pressure. According to Tefera et al. (2011), the potential impact on poverty reduction and greater livelihood security will not be realized, however, if farmers are unable to store grains and sell surplus production at attractive prices.

The majority of farmers use cereal production, including barley and durum for self-consumption, and soft wheat is essentially a sales crop. Barley is only marketed in a year of abundant production. Farmers deliver their harvest to wholesalers (38%) or to the market (32.4%) when it comes to certain bags *(Figure 2).*

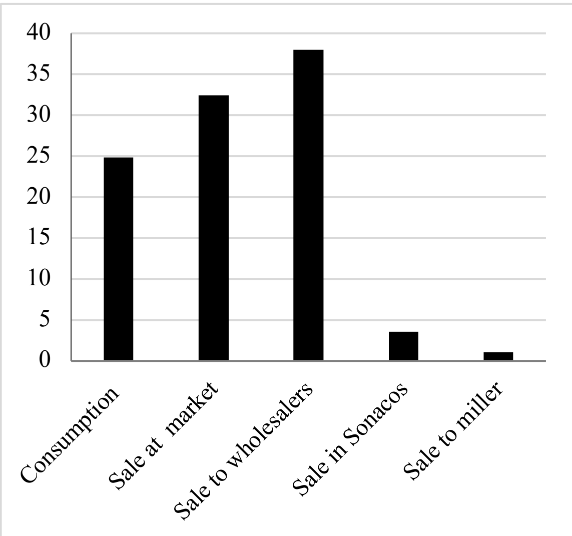

Figure. 2. Destination of seeds harvested by farmers

3.3. Types of storage encountered in the area

In rural areas, traditional conservation methods are often quite simple, sometimes offering very effective results. There are several types of peasant storage structures depending on the different stations in the region. These structures play a very important role in the conservation of the grains and once they are improved, they could play a very important role, which would allow to considerably reducing the losses due to bad storage. According to Fleurat-Lessard (2015) for long-term conservation, it states that it was necessary to comply with a number of rules regarding grain temperature and storage room.

In addition, there are several traditional village storage techniques, such as underground warehouses to store several tons of grain for a long time. The baskets which are made of shards of petioles and rachis palms, are used for small grains like wheat and barley, but this only allows to store small amounts of grain. In other cases, more structures are the traditional granaries for small quantities and stores when it comes to a stock of several tons with a percentage of 59.46% and 30.23% respectively. This study has allowed us to better understand the storage conditions in rural areas. The storage of cereals in this study area varies from 3 months to one year. The frequency of use of each storage structure varies according to the localities and the quantity of seeds stored.

3.4. Major pests identified in the storage areas

The results obtained in this study reveal that losses caused by insects can reach all stored seeds. However, insects are those that currently hold farmers' attention and consider them as a criterion for judging the quality of their seeds. The main pests responsible for losses are seed weevils (*Sitophilus granarius*), tribolium (*Tribolium castaneum* (Herbst) or *Tribolium confusum*), *cereal alucites* (*Sitotroga cerealella*) which are capable of causing dramatic losses in the absence of control *(Figure 3).*

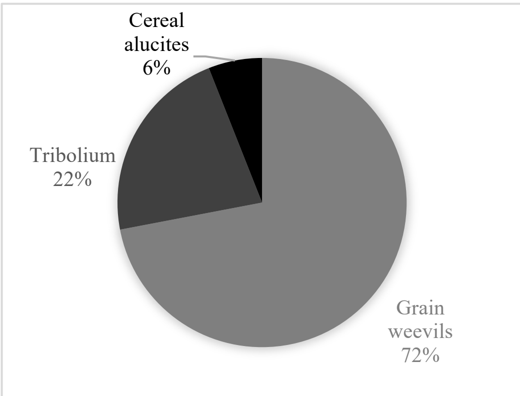

Figure. 3. Pests of grain storage

The results of our investigation revealed that crops were damaged in storage structures by pests. Farmers estimated that 72% of the weevils that can reach all stored seeds *(Figure 4).* A similar study carried out in Edirne province, Turkey, showed that *Sitophilus granarius*, *Sitophilus oryzae*, *Tribolium castaneum* and *Tribolium confusum* were the most common and dense insect pest species in warehouses and mills (Toğantimur and Özder, 2019).

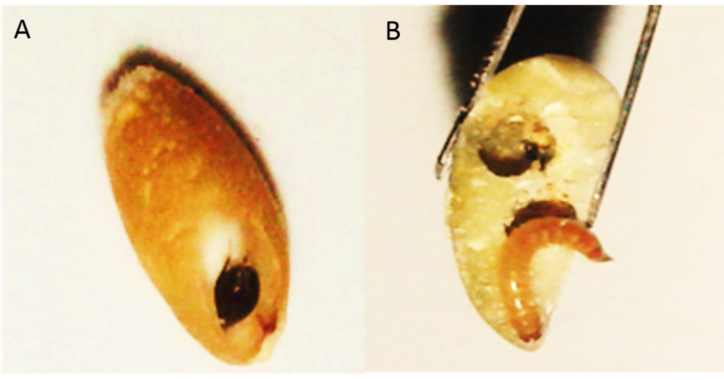

Figure. 4. Adult of Tribolium castaneum inside the seed and (A) Larva of Tribolium castaneum (B)

According to Abass et al. (2014) farmers estimated that weevils accounted for 36% of the total corn loss, while large grain borers accounted for more than half of the losses recorded for corn. In Ethiopia, the stored wheat seed has recorded average percentage damage of 3.6-13.6% which is caused by the major insect pests *Sitophilus granarius*, *Sitophilus* spp. *Sitotroga cerealella*, *Tribolium* spp., *Plodia interpunctella* and *Liposcelis* spp. (Kalsa et al., 2019). Another study conducted in Punjab (India) to evaluate the losses of the main stored wheat insect pests (*Triticum aestivum* Linn.) showed a high incidence of small ruminant (*Rhyzopertha dominica*), followed by rust beetle (*Tribolium castaneum*), rice weevil (*Sitophilus oryzae*) and rice moth (*Corcyra cephalonica*) (Singh, 2016). In addition, monitoring data in granaries and mills in Alexandria (Egypt) identified *Tribolium castaneum* and *Sitophilus oryzae* as the most abundant species infesting wheat (Attia et al., 2020).

3.5. Lack of knowledge about insecticide application

The results obtained in this study revealed that the majority of respondents favor the use of synthetic insecticides (91%), either controlled insecticides or other illegal products that affect public health, food safety, and the economy of the country. According to Ahouangninou et al., (2011), populations will probably not wait to notice the presence of insects in their stocks before starting insecticide treatments. These insecticides are purchased in several forms, either insecticide tablets recommended for external use between bags, or insecticidal powders that mix with the seeds before bagging *(Table 1),* to control insect pests in stocks of cereals with an average shelf life of 6 months.

One of the types of insecticides most used by about 62% of respondents is Aluminum phosphide (PAl), it is a fumigant pesticide used in the storage and protection of stored grain. Nevertheless, currently its marketing and public use are prohibited in Morocco because of the dangers of handling Phostoxin®. However, 38% of farmers use insecticidal powders above the recommended dose.

***Table 1**. Different insecticides application and doses reported by the respondents*

Active ingredient	Formulation	Doses and applications reported by actors	Doses and recommended applications
Aluminum phosphide	Fumigant	2 to 3 fumigants inside the bags	2 to 3 fumigants / m^3 between the bags
Malathion	Powder	without dosing	50g/ 100Kg mixed with seeds
Deltamethrine	Powder	Bag of 50g/100Kg to 300Kg of seeds or without dosing	50g/100Kg mixed with seeds or directly sprayed on seeds

The results obtained in this study reveal that some of them applied very high doses and misused insecticides, for example, placing two to three Aluminum phosphide tablets inside the bags in direct contact with the seeds. This is justified by the fact that the product used is no longer effective as before and does not allow the total eradication of insects. These fumigants such as methyl bromide and phosphine are still the most effective for protection against insect infestation of stored food, feed, and other agricultural products (Kim et al., 2003). Nevertheless, after a long application, many insects have become resistant to organic insecticides. This has led to an increase in applied doses of pesticides, so the effectiveness of this application is optimal (Ramade, 1995; Regnault-Roger et al., 2005). The actors use Phostoxin® sometimes mixed with other insecticides to obtain a more effective product especially when storage lasts several months. Although effective, their repeated use for several decades has disrupted the biological control system by natural enemies and led to insect pest outbreaks, widespread resistance development, and adverse effects on non-target organisms and environmental and human concerns (Champ and Dyte, 1977).

3.6. Insecticide user profile and the existence of risks

Insecticides are poisons that kill insects and can be very dangerous to humans and pets, especially when these insecticides are used improperly and without applying the necessary precautions. Our results showed that not all precautions were respected, and no farmer adopted full-body coverage when applying insecticides. Except a few who use gloves or shawls to replace masks. Also noted that only 20% of those questioned know that there is a possibility of risks of poisoning by insecticides when the dose and use of the insecticide are not respected. Lack of protective equipment when applying chemicals is a violation under Article 2 of the Code of Conduct of the FAO (Food and Agriculture Organization of the United Nations, 2013). It should also be noted that among those who use the chemicals, no peasants know the active ingredient of the substance they use because of the low level of education of these people. According to Zongo et al. (2015) the use of insecticides sometimes at very toxic doses, their poor instructions for use and the non-respect of the duration of persistence of the insecticide (varies between 1 to 3 months) are factors food poisoning and the low level of education of producers and traders mean that they do not know how to use insecticides, which increases the risk of poisoning. In addition, there are sometimes more serious health consequences such as problems of infertility or cancer development, immunodeficiency, neurodevelopment and behavioral disorders, metabolic disorders, and diabetes (Idrissi et al., 2010).

This situation has shown the risk to which consumers are exposed and the real danger that can cause these types of applications for human health. According to Multigner (2005), the delayed effects of pesticides on human health may be the consequence of past exposure, usually intense or of low intensity but repeated over time, potentially of the population, exposed professionally or by the environment (air, water, food).

Prior to the development of synthetic insecticides, materials of plant origin provided a means of crop protection. These botanical insecticides have certain advantages; they do not persist in the environment, they pose a relatively low risk to non-target organisms (predators and beneficial parasites) and they are relatively non-toxic to mammals (Scott et al., 2003; Weinzierl, 2000). Biological control is currently the recommended method for controlling insects in the stock. However, these technologies must be simplified and popularized among Moroccan farmers to avoid the various problems associated with the use of synthetic insecticides.

4. Conclusion

The study presents an unconscious image of the use of synthetic insecticides by people surveyed in our study area, resulting in a selection of resistance in pests. The consequences of misapplication are numerous and are not limited to treatment effectiveness issues alone, but can also have negative impacts on human and animal health. On the one hand, these results are alarming and suggest that these management practices for cereal stocks would be controlled for the population concerned and that the various actors should be made aware of the increased risks of the misuse of these insecticides. On the other hand, the search for other alternatives such as biological insecticides are essential. Studies have been planned to evaluate the use of natural products in protecting stored grains and legumes.

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