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Research Paper

Pesticides used by Moroccan's farmer in oriental Morocco: Case of Berkane region

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ABSTRACT

The region of Berkane in Oriental Morocco is well known for his high agricultural activity; indeed this implies the use of pesticides. But pesticides have harmful effects; they can cause injury to human health as well as to the environment. The range of these adverse health effects includes acute and persistent injury to the nervous system, lung damage, injury to the reproductive organs, and dysfunction of the immune and endocrine systems, birth defects, and cancer. The present article was a field investigation near the pesticides society on pesticides used in the area of study in term of quantity and chemical families used and their toxicity, we also assess the ratio of use in the area of study (7 kg/ha). Indeed the Organochlorines (OC) and the Organophosphates (OP) are the most used, and also the most toxic for human health and persistent in the environment. The application rate per hectare in the area of study (7 kg/ha) is less than the national ratio of use (8.3 kg/ha); we also found that some forbidden pesticides (Dicofol) in developed countries were still used in Morocco.

Key word: Pesticides, application rate, toxicity.

INTRODUCTION

In 1937, the population of Morocco was about 7 millions. It was doubled in 1971, and reached 26 millions in 1994 (Tabutin et al., 2001). Recently in 2003, the population has grown to about 30 millions with a growth rate of 1.5% annually. At the same rate of growth, the population of Morocco after 22 years (year 2025) may exceed 40 millions. Subsequently, the balance between population increase and production of enough food is therefore one of the most important and challenging problems facing Morocco today. So, the use of pest control agents (e.g., pesticides) in agriculture was, and will remain for the foreseeing future, an essential component and a prerequisite for increasing productivity of the land in Morocco. The pesticides used in agriculture are more known by "phytosanitary product", and the classification of pesticides in agriculture depends on the target organism so we distinguish:

(i) Insecticide: chemical used against insect.
(ii) Fungicide: chemical targeting the fungi.
(iii) Herbicide: Products which eliminate or has effect on herb growth.
(iv) Acaricide: chemical designated to eliminate the mites.
(v) Molluscicides: eliminate the mollusks.
(vi) Rodenticide: targeting the rodents.

They are other classifications based on several criteria. As indicated by Hornsby (Hornsby et al., 1996), a classification based on chemicals class, we found on the database of PAN « Pesticide Action Network » 340 pesticides grouped in 45 chemicals families. There is also a classification of pesticides by hazard established by the World Health Organization (WHO, 2009), so we found 5 WHO class:

Class Ia: Pesticides extremely hazardous, the LD_{50} for the rat (mg/kg body weight) is < 5 mg for the oral ingestion and < 50 mg for the dermal.
Class Ib: highly hazardous, the LD_{50} for the rat is between 5-50 mg for the oral ingestion and 50-200 mg for dermal.

Class II: Moderately hazardous, the LD_{50} is between 50-2000 mg for the oral intoxication and 200-20000 mg for the dermal intoxication.
Class III: Slightly hazardous, the LD_{50} over than 2000 mg for the oral and dermal intoxication.
Class U: unlikely to present acute hazard, the LD_{50} is over than 5000 mg.

At the global level, the use of pesticides has proved to assist solving of many problems facing human health and food production. However, such usage has occasionally been accompanied with hazards to man and the environment, and considering their toxicological properties, persistence, presence and concentration in the food chain they constitute a true danger for the environment and the Human well being (Rakitsky et al., 2000). According to the WHO, developing countries use about 20% of the pesticides in the world, and this rate of use is increasing year after year (WHO and UNEP, 1990).

At national, regional, and international levels, the problem of pesticide harm should be handled scientifically within collaborative action plans; to take as much benefits as possible from using these toxicants without significant hazard to human beings. To promote initiation of the concerned plans, the situation of pesticides in each country should be thoroughly investigated and clarified, so let take an overlook on pesticides world market.

TRENDS AND PATTERNS OF PESTICIDE USE

The world pesticide market

Data on worldwide pesticide sales and use are really difficult to find. FAO surveys agricultural ministries in each country regarding pesticide use every year, but responses are not always reliable (Curti, 1994). In dollar terms, about 62% of the 30 billion US$ pesticide market in 1995 was in the United States, Western Europe, and Japan. In weight of active ingredients, only 55% of the market was in developed regions. Many of the banned or withdrawn pesticides from developed markets are still produced and sold in developing country markets, either by domestic companies or by some multinationals acting through subsidiaries or joint ventures. These include DDT and other persistent organochlorine (OC) insecticides, which represent about 15% of the value of insecticide sales in regions outside USA, Western Europe, and Japan (Mackenzie, 1994). The older and more toxic organophosphorus (OP) and carbamate insecticides and herbicides also have very significant sales in the Third World (e.g., alachlor, aldicarb, benomyl, captan, carbofuran, chlordane, cyanazine, dimethoate, endosulfan, EPN, mancozeb, lindane, monocrotophos, paraquat, parathion, toxaphene, zineb, carbaryl, atrazine, glyphosate, 2,4-D, dichlorovos, phorate, and many others). During the nineties, the pesticide market in developing and transitional countries exceeded US$ 2.0 billion per year (WRI, 1996). Globally, organophosphates account for nearly 40% of total insecticide sales by value, followed by carbamates (20.4%), pyrethroids (18.4%), and organochlorines (6.1%). However, organochlorines are used almost entirely in developing and transitional economies, partly for public health vector control and animal health programs (MacKenzie, 1994).

Regional pattern

Pesticide use in Africa is the lowest overall of all the continents because of poverty, instability, unreliable rains, and indifferent soils have kept smallholder agriculture from modernizing in much of the region. However, there are areas of intensive pesticide use across North Africa, for example the cotton-growing regions of Sudan. Large-scale commercial farms and plantations producing coffee and other export crops in South Africa (e.g., Zimbabwe, Kenya) are also chemical-intensive. Many of the (OC) pesticides, which have been banned or whose use has been severely restricted in Europe and North America, are still marketed and used in Africa (Szmedra, 1994).

Costa Rica (18.0 kg/ha), Belize (17.4), South Korea (10.0), Morocco (9.9), and Malaysia (9.2) are among the most intensive pesticide users (Dinham, 1994, 1993; Szmedra, 1994; WRI, 1994; PAN, 1989) but, even in countries where per hectare application rates are lower, persistent or hazardous pesticides, unsafe practices, or geographically concentrated patterns of use can create significant exposure risks for large populations. The overall picture emerges of heavy and growing use of highly risky pesticide products in large parts of the developing world.

Moroccan pesticides market

Morocco imports per year between 10.000 to 12.000 tones of pesticides, this number is increasing years after years, (Charkawi, 2006), which constitute 800 phytosanitary product, included 270 molecules distributed as shown in Table 1.

The sales reaches the 100 million dollars (Charkawi, 2006) however the statistics given by FAO shows that since 1990 the consumption of Morocco increased considerably passing 5000 tons in 1986 to 12.000 tons in 2004. The pesticides in Morocco are imported by nearly 50 companies which are direct subsidiary companies of the multinationals (Diab, 2007), inside the country, the distribution is currently assured by the distributers, the retailers, the cooperatives, the private companies and by public deal of some official institutions, we counts more than 724 point of sale (Charkawi, 2006). The Table 2 shows the market trends of the pesticides in Morocco.

Table1. Category of pesticides imported in Morocco (Charkawi 2006).

Class of pesticides	Percentage
Insecticides	39
Fungicides	35
Herbicides	11
Nematicides	11
Others	4

Table 2. Moroccan market of pesticides imported between 1991 and 2006 (in million US$) according to department of statistic in FAO.

Year	1991	1992	1993	1994	1995	1996	1997	1998
Millions US$	39	37	30	42	44	54	51	62
Year	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**
Millions US$	54	50	53	55	82	100	88	94

As shown in Table 2, the increase in consumption is not linear because of the climatic disturbances, and the years of dryness, and it also depends on demand in this chemical to face global plague (like locust in 2004). But in Moroccan case we must specify this is a lack of data on pesticide, indeed it's hard to find what kind of pesticides is used and the quantity sale to farmer or the chemical families used, this information are important to put a risk assessment on environment and human health. So that's why in the current papers we attempt to highlight the quantity used of this chemical and the most families class used, in Berkane region located in Oriental Morocco, by conducting a query near the sellers, and provide data on pesticides toxicity and bioaccumulation of pesticides residues in different environmental component.

METHODOLOGY

Area of study

The area of Eastern Morocco is located, as shown in Figure 1 in East north of Morocco. It is limited to North by the Mediterranean, the East and the South by the Algerian borders, in the West by the provinces of Alhoceima, Taza, Boulmmane and Errachidia. The Eastern Morocco is the second largest region in the kingdom, in terms of superficies; it covers an area of 52,820 km^2 or 11.6% of the total area of the country. The majority of agriculture within the area of Eastern Morocco concentrates on the level of lower Moulouya irrigated perimeter (Figure 2) which extends on 160.000 ha of arable land, including 80.000 ha irrigated. The province of Berkane, when we conduct our inquiry, is about 60.000 ha of arable land with 40.000 ha irrigated so the half of irrigated land in this perimeter.

The principal's cultures in this area are: Clementine, cereal cultures and Truck farming (potato, tomato, artichoke….). According to the data provided from ORMVAM (the Regional Office of Agricultural Valorizations of Moulouya), the production of citrus exceed 250.000 tons in 2006 (20% from national production), also 10% from national production of potato. So we can say that this region are very important to economy of the country if we know that the agriculture participle to GDP of Morocco with 17% (High Commission Plan, 2006).

Inquiry

Our investigation was done in the agricultural campaign during 2008/2009, we elaborate a questionnaire that contains question about the sellers degrees, age (Data not shown), commercial name of chemicals sell, and the quantity soled. The data was gathered near 6 societies of pesticides implanted in the area, and 5 resellers of phytosanitary product. The total of person implicated is 11 with an age's bracket between 25 to 63 years.

After the commercials names of product was identified with ACTA phytosanitary index 2008 with the aim to identify the activate molecule of this products. We must mention that every societies has a different name for the same active ingredient so to identify them we must use the phytosanitary index provided from ACTA, the Association of phytosanitary industrial in France ho publish every year an index on pesticides marketed.

RESULTS AND DISCUSSION

The Table 3 regroup the results of the investigation, its

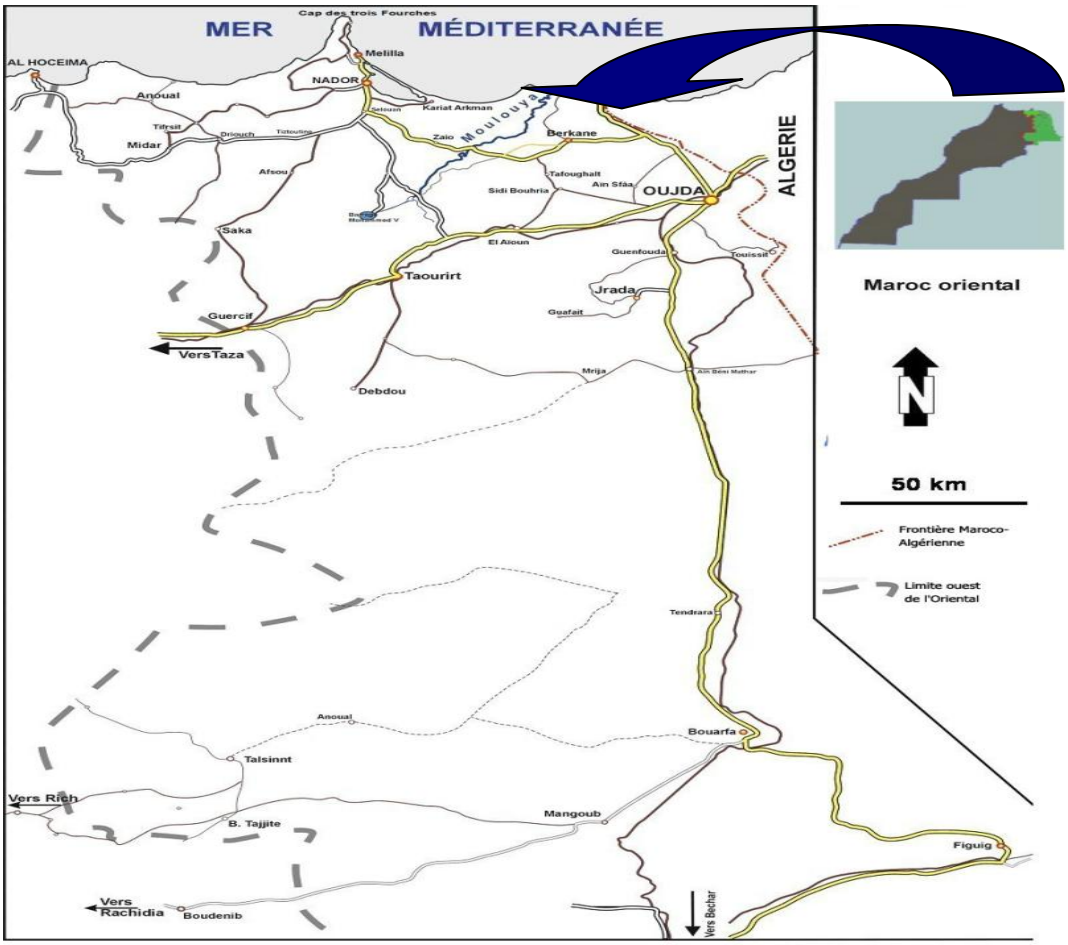

Figure 1. The oriental Morocco.

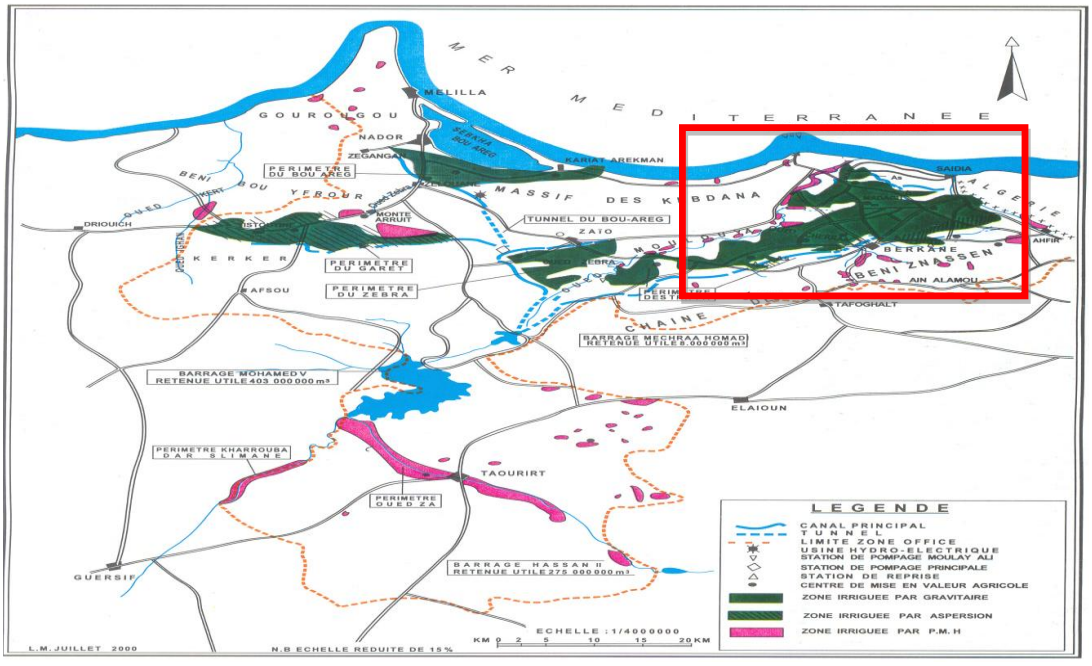

Figure 2. The perimeter of lower Moulouya in the box region of 'Berkane.'

Table 3. Commercial name of pesticides their uses, their chemicals family and quantities.

Commercial name	Insecticides	Fungicides	Herbicides	Active ingredients	Quantities (kg)
Dursban	X			Chlorpyriphos-éthyl	50000
Pyrical	X			Chlorpyriphos-éthyl	23000
Malathion	X			Malathion	22000
Mamba			X	Glyphosate	16000
Promazite		X		Thirame	14000
Liberoate	X			Dimethoate	19000
Dimethoate	X			Dimethoate	8000
Managri		X		Manèbe	13000
Turbo		X		Mancozèbe	15800
Prosulfan	X			Endosulfan	23000
Exocide	X			Endosulfan	11000
Thiodan	X			Endosulfan	4000
Lannate	X			Methomyl	8000
Zynorale		X		Zinèbe	12700
Ultracide	X			Méthidathion	16000
champion		X		Hydroxyde de Cu	6700
Diafiron	X			Diazinon	4000
Profol	X			Dicofol	8000
Mancozèbe		X		Mancozèbe	4.050
Entracol		X		Propinèbe	2500
Cyrux	X			Cyperméthrine	2000
Decis	X			Deltamethrine	2000
Total= 281 750 kg					

Table 4. Pesticides types and quantities (kg).

Pesticides type	Quantities (kg)	Percentage
Insecticides	200 000	71
Fungicides	65 750	23
Herbicides	16 000	6

show the commercial name of the product, their use (insecticide, fungicide etc), chemical family and lastly the quantities sold. The total amount of pesticides sold, tons during the agricultural campaign 2007/2008, was estimated to about 282 tons (Table 3), in region of north Morocco, in perimeter irrigated of loukkous (130.000 ha), a similar investigation show that is more than 800 tons is used per year (El Bakouri et al., 2008).

The quantities found is about 282 tons and the irrigated land in the region of study is 40.000 ha, and by doing a simple calculus: the quantities of pesticides used (kg) divided by the land (ha), we found that the application rate of pesticides per hectare are 7 kg/ha and the national ratio was 9.9 kg/ha according to Dinham (1994, 1993), Szmedra (1994), WRI (1994), PAN (1989). Actually in 2009, the national ratio is about 8.3 kg/ha (12000 tons/1445000 of irrigated land) so in theory we must found 332 tons used per year (40 000 ha × 8.3 kg/ha), the difference is 1.3 kg/ha (50 tons). We can explicate this difference between the estimated quantity and the real one, it's may be due to the use of pesticides sold in the black-market, because their lower price, indeed this region know a important contraband activity, if we know that the region of study is located near the Algerian border and Spanish border (occupied Mellilia). We have to also note that the national ratio can change in different region of the country if we take for example the North Morocco, the rate of use is 6.6 kg/ha (El Bakouri et al., 2008). Another remark that the difference between the quantities found, and the estimated can be attributed to the farmers themselves (behavior, pesticides use), so this point must be studied and clarified to highlight the origin of this difference.

As shown in Table 4, there are 3 classes of pesticides used in the area of study, insecticide fungicides and herbicides, but the majority of the chemical sold are insecticides with 71% followed by fungicides 23%. We can explicate this that

Table 5. Class of chemicals family of pesticides recessed.

Chemicals families	Quantity (kg)
Organophosphorus	150 000
Organochlorines	38 000
Carbamates	62 050
Glycines	16 000
Copper hydroxide	6700
Dicofol	4000
Pyrethrynoïd	4000

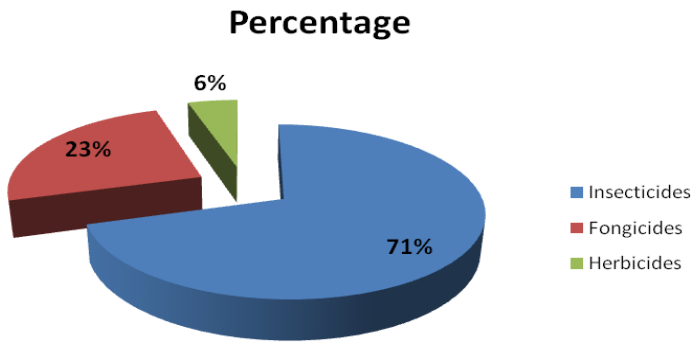

Figure 3. Percentage of classes of pesticides used in Berkane.

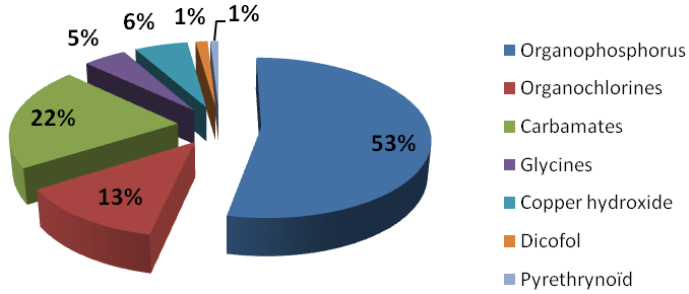

Figure 4. Percentage of pesticides chemicals families.

the climate in this area is a Mediterranean semi dry, with 300 mm annually average rainfall. In humid region of Morocco like North of the kingdom or the West the fungicide are the mostly used, so in loukkous (North of Morroco) region the fungicide take the lead with 64% the insecticides with 19% (El Bakouri et al., 2008).

The result (Table 5 and Figure 3) show that the major chemical family is: organophosphorus, the carbamates and then the organochlorines, there are other chemical families as shown in Figure 4, is evident that the organophosphorus is dominant, because they are all insecticide the same thing for organochlorines, the carbamates regroup insecticides and fungicide. This 3 most used family regroup a very toxic compound for environment and health. The organochlorine (OC) pesticides are highly toxic man-made chemicals that persist in most environmental compartments, including the atmosphere, soil, water, sediments, and biota (Doong and Liao, 2001; Goerke et al., 2004; Grimalt et al., 2001; kurt and Ozkoc, 2004; Sapozhnikova et al., 2004; Vorkamp et al., 2004). Although industrialized nations have restricted or banned many OC pesticides (Vega et al., 2007), some of them, e.g., DDT, remain in use as feedstock for dicofol production (Van de Plassche et al., 2003). Many OC pesticides are persistent and lipophilic, favoring their widespread accumulation in adipose tissues (Kutz et al., 1991). Indeed many study has prove the presence of OC or/and their metabolites (like endosulfan, lindane, DTT) in food (Fontcuberta et al., 2007; Commission of the European Communities, 2006) water (El Bakouri et al., 2008; Abouzaid and Echihabi, 1995; Cerejeira et al., 2003) and sediment (Liu et al., 2007; Bettinetti et al., 2003; Chernyak, 1995). The organophosphorus (OP) are anti-cholinesterase insecticides, inhibit the cholinesterase, regardless of their efficiency, they are extremely hazardous. In effect in bibliography, the acute health effect of OP are well characterized (Alderman et al., 1978; Jeyaratnam et al., 1987; Hayes and laws, 1991; Wesseling et al., 1993; Clarke et al., 1997), another problem linked to their anti-cholinesterase activity is that they have effect on non target organisms (like bird, bee, fis), indeed they cause a major disturbance in environment equilibrium, several study has discuss this problem (Busby et al., 1991; Fleischli et al., 2000; Martınez-Haro et al., 2006). Organophosphorus residue or their metabolites are also found in different kind of food: vegetable, fruit, fish (Ashour et al., 1987; Bhanti and Taneja, 2007; Kumari et al., 2004) and underground water in our area of study (Benaboud and El Achouri, 2010).

Conclusion

The use of pesticides is very hazardous to the man and environment, our study has highlighted the quantity of phytosanitary product used in Berkane region. The study has also shown that there are very toxic activate compound used in this area and also a forbidden one in Europe: the Dicofol (banned from France in 2009) because it is a derivative of DTT. The lack in legislation to control these chemicals must be filled by the government, and update the list of forbidden pesticide and enhance the control of toxic agent since the Morocco government have signed and approved the Stockholm convention and Rotterdam convention. But a further study must be established on their presence in different compartment of environment (soil, water, air), and also agricultural product, especially potato and citrus because they are the major agriculture in the area. The difference found between the estimated ratio of use and the real ratio of use, also must be clarified with a

pushed investigation with the farmer, and this must be clarified with a study on Knowledge Attitude and Practice (KAP), that we have already established in a similar study on farmers of Berkane in the same agricultural campaign (2008/2009).

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