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Is organic farming safer to farmers' health? A comparison between organic and traditional farming

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HIGHLIGHTS

- There are no previous studies on the impact of organic farming on workers' health.
- Genetic damage and immunological alterations of workers were studied.
- Results confirm increased DNA damage levels in farmers exposed to pesticides.

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ABSTRACT

Exposure to pesticides is a major public health concern, because of the widespread distribution of these compounds and their possible long term effects. Recently, organic farming has been introduced as a consumer and environmental friendly agricultural system, although little is known about the effects on workers' health. The aim of this work was to evaluate genetic damage and immunological alterations in workers of both traditional and organic farming. Eighty-five farmers exposed to several pesticides, thirty-six organic farmers and sixty-one controls took part in the study. Biomarkers of exposure (pyrethroids, organophosphates, carbamates, and thioethers in urine and butyrylcholinesterase activity in plasma), early effect (micronuclei in lymphocytes and reticulocytes, T-cell receptor mutation assay, chromosomal aberrations, comet assay and lymphocytes subpopulations) and susceptibility (genetic polymorphisms related to metabolism - *EPHX1*, *GSTM1*, *GSTT1* and *GSTP1* - and DNA repair–*XRCC1* and *XRCC2*) were evaluated. When compared to controls and organic farmers, pesticide farmers presented a significant increase of micronuclei in lymphocytes (frequency ratio, FR = 2.80) and reticulocytes (FR = 1.89), chromosomal aberrations (FR = 2.19), DNA damage assessed by comet assay (mean ratio, MR = 1.71), and a significant decrease in the proportion of B lymphocytes (MR = 0.88). Results were not consistent for organic farmers when compared to controls, with a 48% increase of micronuclei in lumphocytes frequency ($p = 0.016$) contrasted by the significant decreases of TCR-Mf ($p = 0.001$) and *%T* ($p = 0.001$). Our data confirm the increased presence of DNA damage in farmers exposed to pesticides, and show as exposure conditions may influence observed effects. These results must be interpreted with caution due to the small size of the sample and the unbalanced distribution of individuals in the three study groups.

1. Introduction

The harmful properties of pesticides have been described for the last decades not only in the environment (Werf, 1996) but also on human health (WHO, 1990). Genotoxicity studies conducted

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in pesticide-exposed populations have found inconsistent results (Bolognesi, 2003; Bull et al., 2006), although the reason of this heterogeneity remains largely unknown. Some authors believe that this variation may be attributable to exposure factors, while others suggest that pesticide exposure can induce an adaptive response, which can modulate adverse effects (Pastor et al., 2002). In addition, population sample size, inadequate experimental data and individual susceptibility greatly contribute to discordant results (Au et al., 1998). Regarding the possible effects of pesticide exposure on the human immune system, there are some studies providing evidence that these compounds, although not antigenic themselves, may alter immune functions (Corsini et al., 2008). Data available in the literature is mainly related to immunosuppression with reports on decrease of %CD26$^+$, %CD4$^+$, neutrophil function, decrease of antibody production by B lymphocytes and decrease of natural killer cells activity among other alterations in pesticide-exposed populations (Colosio et al., 1999; Corsini et al., 2008; Li, 2007).

Although many hazardous pesticides have been recently withdrawn from the European market, numerous compounds registered are still used, provoking serious and scientifically documented consequences for human health. In 2009, Pesticides Action Network (PAN) Europe identified several pesticides in use which are classified by different organizations as cancer-causing, toxic to the reproductive system, genotoxic or endocrine disrupting (PAN, 2009). Besides, in the last decades, organic farming became popular among people as there is a widespread belief that organic agricultural systems are friendlier to the environment and consumer than traditional farming systems. Nevertheless, studies that tried to establish a link between organic food consumption and consumers' health were mainly inconclusive as there are a large number of confounding factors that impair any inference (Dangour et al., 2009). Regarding workers' health, outcome from different agricultural systems is limited to a few observation studies of sperm quality (Jensen et al., 1996; Juhler et al., 1999) that also obtained conflicting results.

The objective of this work was to study genetic and immunological alterations in workers of two different types of agricultural systems (organic and traditional) using a multistage approach in order to integrate information obtained with biomarkers of exposure, effect and susceptibility. Biomarkers of exposure included determination of pesticides in urine, namely pyrethroids, organophosphates and carbamates, excretion of total thioethers in urine and enzymatic activity of plasma cholinesterase. Biomarkers of effect comprised the study of genetic damage with different assays: micronucleus (MN) evaluation (both in lymphocytes and reticulocytes), chromosomal aberrations (CA) test, DNA damage–evaluated by means of comet assay–, and also somatic mutation [T-cell receptor (TCR) mutation assay]. In addition, alterations in the immune system were also assessed using lymphocyte subsets analysis. The potential role of genetic polymorphisms in genes related with the metabolic fate of pesticides (*EPHX1*, *GSTM1*, *GSTT1* and *GSTP1*) and DNA damage repair (*XRCC1* and *XRCC2*) in modulating individual levels of biomarkers related to pesticide effects was also evaluated.

To our knowledge, this is the first study that compares genetic and immunological damage among workers that are involved in the traditional and the organic farming systems.

2. Materials and methods

2.1. Study population

The group of traditional agricultural system consisted of 85 farmers using pesticides (43 males and 42 females) from a main Portuguese agricultural (horticulture) area (Povoa de Varzim and Esposende; within Oporto district). Four months of pesticide exposure was considered the cut-off point for inclusion in exposed group. The group of organic agricultural system was composed of 36 organic farmers not using pesticides (17 males and 19 females) from the same geographical area (Oporto district) and also producing horticultural products. The control group comprised 61 acquaintance non-exposed individuals (26 males and 35 females), living in the same area and with no history of occupational exposure to pesticides or other genotoxic agents. All individuals were Caucasians. Characteristics of the studied groups are presented in Table 1. All subjects were fully informed about the procedures and objectives of this study and each of them signed an informed consent prior to the study. Ethical approval for this study was obtained from the institutional Ethical Board of the Portuguese National Institute of Health.

In a face to face interview, each subject gave the necessary information on demographic features such as age, gender, smoking habits and also to determine possible additional confounding factors such as X-ray exposure, previous and current medication.

Individuals included in organic farmers group were all certified organic farmers and therefore working in compliance with EU Regulation 834/2007 and 889/2008 for at least four months; these regulations describe all the necessary requirements for certified production and indicate sensitive issues such as chemicals usage (allowed under authority's control) and land requirements. In the face-to-face interview, all individuals stated that the usage of allowed substances was absolutely exceptional and therefore in this study, we consider organic farmers as not exposed to those products. Organic farmers had no previous history of occupational exposure to pesticides or other genotoxic agents.

Exposed subjects also gave information concerning work tasks, years of employment, workplace, occurrence of previous intoxications (those resulting of pesticide exposure that required medical treatment) and details on their last exposure to

Table 1
Characteristics of study group.

	Study group		
	Unexposed controls (n = 61)	Organic farmers (n = 36)	Pesticide workers (n = 85)
Age[a] (year)	39.5 ± 12.3 (19–61)	39.6 ± 14.5 (18–68)	40.0 ± 12.2 (18–63)
Gender			
Males	26 (42.6%)	17 (47.2%)	43 (50.6%)
Females	35 (57.4%)	19 (52.8%)	42 (49.4%)
Smoking habits			
Non-smokers	50 (82.0%)	31 (86.1%)	80 (94.1%)
Smokers	11 (18.0%)	5 (13.9%)	5 (5.9%)
Cigarettes/day			
<15	5 (45.5%)	1 (20.0%)	4 (80.0%)
≥15	6 (54.5%)	4 (80.0%)	1 (20.0%)
Task			
Non-applicator			30 (35.3%)
Applicator			55 (64.7%)
Workplace			
Open-field		14 (38.9%)	13 (15.3%)
Greenhouses			6 (7.1%)
Both		22 (61.1%)	66 (77.6%)
Duration of employment[a] (years)	9.5 ± 12.3	22.7 ± 16.2	
Pesticide preparation			
No			30 (35.3%)
Yes			55 (64.7%)
Chemical class of Pesticide (last reported exposure)[b]			
Pyrethroids			6 (7.1%)
Carbamates			20 (23.5%)
Organophosphates			17 (20.0%)
Other			32 (37.6%)
Use of PPE			
No			25 (29.4%)
Yes			60 (70.6%)
Inadequate usage of pesticides			
No			67 (78.8%)
Yes			18 (21.2%)
Season			
Autumn–winter	61 (100%)	26 (72.2%)	46 (54.1%)
Spring–summer	0	10 (27.8%)	39 (45.9%)

[a] Mean ± SD (range); PPE: personal protective equipment.
[b] Ten of the exposed individuals were not able to report the chemical concerning their last exposure.