



Farmers' exposure to herbicides in North Italy: Assessment under real-life conditions in small-size rice and corn farms

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ABSTRACT

Although rice and corn are two main cash crops in Lombardy (North Italy) and their cultivation involves several thousands of farmers, risk assessment of pesticide exposure is rarely done, especially in small and medium sized enterprises. With the use of pads for environmental monitoring (OECD protocol), of pre- and post-exposure 24 h urine collection for biological monitoring and of hand wash for hands' exposure, we measured the exposure of 28 agricultural workers to propanil and terbuthylazine in real-life working conditions. In propanil applicators, median daily exposure on the clothes was 73.5 μmol per worker, while the exposure on the skin was 22.4 μmol . For terbuthylazine, these exposures were 37.2 μmol and 0.86 μmol per worker, respectively. Median excretion of the propanil metabolite (3,4-dichloroaniline) after exposure was 84 nmol in 24 h urine, and 13 nmol for the metabolite of terbuthylazine. Risk assessment performed by comparing to the AOELs of the applied active ingredients with an estimated internal dose, obtained based on the measured levels of skin and hand exposure and the percentage of dermal absorption of the active ingredients considered showed that 4 propanil workers, and no terbuthylazine workers, were overexposed. Our study helps define and confirm relationships between different exposure determinants, which can be used in the development of tools for risk assessment of exposure to pesticides in small and medium sized enterprises.

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1. Introduction

In Lombardy (North of Italy), rice and maize are two main cash crops; rice (about 600,000 metric tons from nearly 100,000 ha in 2008) as human food, and maize (about 3 million metric tons from nearly 250,000 ha in 2008) mainly as cow and pig fodder (ISTAT, 2009). The production cycle of both crops is similar and weeds herbicide treatment is performed for the first time in the season

immediately after seeding and before newly germinated plants grow ("pre-emergent treatment"). Depending on the season and on the growth of aggressive weeds in the crops, also a "post-emergent" treatment can be performed. Molinate, propanil and terbuthylazine are among the active ingredients used for weed killing.

Exposure of agricultural workers to herbicides occurs in rice and maize farming and risk assessment is necessary to protect their health by preventing unacceptably high exposure. Unfortunately monitoring operator exposure and chemical risk assessment in this sector are seldom performed, in particular for the small-size and family-based enterprises (SSE). Moreover, exposure levels of agricultural workers to propanil and terbuthylazine are scarcely investigated.

In general, factors which hamper risk assessment in agriculture are the variability of the working and climatic conditions (Arbuckle

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et al., 1999; Harris and Solomon, 1992; Harris et al., 1992; Moody et al., 1992) and, for chemical risk assessment, the use of complex and variable mixtures of compounds (Hines et al., 2001), which generate an intrinsically high variability of biological and environmental measurements (Machera et al., 2003). Moreover, real-life exposure measurement is very expensive due to the necessity to measure trace levels of specific chemical compounds in complex matrices with highly sophisticated and expensive equipment (Hoppin et al., 2006; Lindh et al., 2011).

Pesticide risk assessment for farmers is based on the knowledge of the mutual relationships between different variables which influence the levels of exposure (“exposure determinants”) in the four typical working phases of pesticide application in agriculture, which are (a) mixing and loading of products, (b) application on the crops, (c) re-entry in the treated field and (d) maintenance and cleaning of equipment and of personal protective devices (PPDs).

An approach to make in-field pesticide risk assessment simpler and easily applicable is to define typical exposure and risk scenarios and to forecast typical levels of exposure has been recently proposed (Colosio et al., 2011). In order to perform the task, it is necessary to find, for each scenario, the relationships between the main variables which affect the levels of exposure of the workers in each of the above mentioned working phases.

Therefore we ran a study in the Region of Lombardy (North of Italy) aimed at collecting information about the above mentioned exposure determinants, their occurrence and their relationship.

2. Material and methods

2.1. General description

This study was performed in 11 rice and 13 maize small-size farms in Lombardy from March 2008 to September 2009. Most farms are provided with occupational health surveillance at the workplace by the International Centre for Rural Health, a World Health Organization Collaborating Centre hosted at the University Hospital San Paolo (Milan, Italy); several others were selected by the Local Health Units which collaborated in the study. We chose small size enterprises, with no more than three employees each, and making use of the herbicides propanil and terbuthylazine, respectively for rice and maize herbicide treatment. Each agricultural enterprise participated in the study with one worker, who was the only one engaged in herbicide application in the farm.

All the workers involved were informed about the aims and the modalities of the conduction of the study before the beginning of the activities and signed informed consent to their participation.

To collect all the relevant data regarding the working activity, a checklist data collection form was used during the day of the herbicide treatment, when a research team composed of an occupational physician, a nurse and an agronomist visited the farm and performed field monitoring and sample collection. Before the beginning of the study, the occupational physician collected selected information regarding presence or absence of diseases and pharmacological treatments. Details on the treated field surface, on the nature and on the amount of applied herbicides, on

Table 1
Position of pads over and under clothes in the investigated farmers.

Pad No	Position	Proportion of body surface (%)	
1	Clothes	Chest	17%
2	Clothes	Right glove	3%
3	Clothes	Right thigh	9%
4	Clothes	Neck	3%
		Total	31%
5	Skin	Chest	17%
6	Skin	Right forearm	3%
7	Skin	Left forearm	3%
8	Skin	Right thigh	9%
9	Skin	Left thigh	9%
10	Skin	Back	17%
		Total	58%

the employed equipment, on the duration of application and on several other relevant details, such as nonscheduled maintenance interventions, were checked and recorded by the professional agronomist.

Farmers' exposure assessment (pesticide amount on the clothes and on the skin) was performed with the application of pads, collection of the hand wash liquid and of pre- and post-application 24 h urine, as described in more detail below. Since this was a two-year project, in two cases the same workers and farms were examined both in 2008 and 2009. In addition, two workers divided their working day into two shifts, and these two shifts were monitored separately. The morning and afternoon shifts were, from the point of view of farmers' exposure, two independent events, since workers changed their clothes and washed themselves at the end of the morning shift. Therefore, at the same time, pads were removed and farmers' hands washing liquids were collected. Analogously, after lunch, the farmers were fitted with new pads for the 'afternoon shift'. Since these observations are considered independent, they were analyzed and elaborated as such. On the contrary, the urine samples were considered to derive from a whole-day exposure, the intensity of which was calculated as the sum of those of the morning and the afternoon shifts. Therefore, a total number of 24 herbicide applicators in rice and maize entered the study, providing a total of 28 external dose-monitoring events (12 for propanil and 16 for terbuthylazine) and for 26 pairs of urine samples (pre and post exposure) for biological monitoring (11 for propanil and 15 for terbuthylazine).

2.2. Collection of environmental monitoring samples

Skin exposure was assessed according to Organization for Economic Co-operation and Development (OECD) guidelines (OECD, 1997) with the use of square 0.01 m² pads made of Whatman no. 1 filter paper (Prodotti Gianni, Milan). Ten pads were placed on the clothes used during application (4 pads), under the clothes on the skin (5 pads) and on the collar, above clothes (1 pad). Pads on the clothes estimate the potential dermal dose, that is the amount of applied active ingredient which reaches the subject; those under the clothes, on the skin, estimate the actual dermal dose, that is the amount of compound able to reach the uncovered skin, available for absorption; the pad applied on the collar both contributes to estimate the potential dermal dose and allows to understand whether exposure *via* inhalation is quantitatively relevant to the global exposure. For details see Fig. 1 and Table 1.

Hand skin exposure was assessed by washing workers' hands at the end of the shift with 200 mL of iso-propanol and collecting the hand wash liquid for analysis.

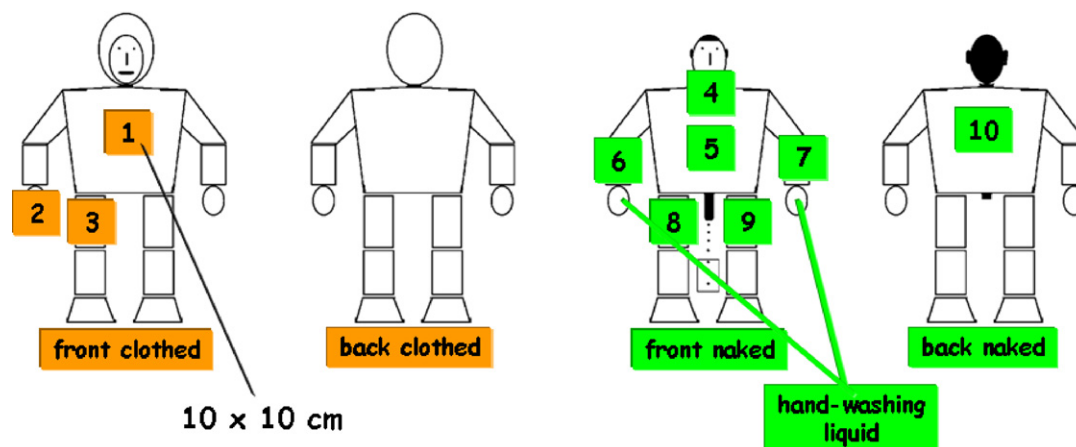


Fig. 1. Placement of pads on farmers' bodies: over the garments (pads 1–3) and under the garments (pads 4–9).

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