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Farmers' use of personal protective equipment during handling of plant protection products: Determinants of implementation

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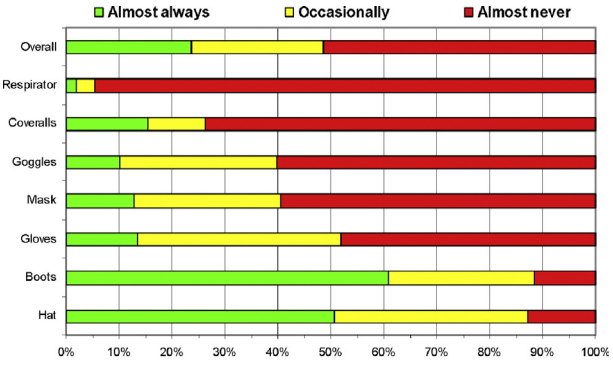
HIGHLIGHTS

- Factors related to PPE use during pesticide handling were explored in northern Greece.
- Most farmers (49.3%) showed potentially unsafe behaviour with respect to PPE use.
- An episode of pesticide intoxication in the past exerted positive influence on PPE use.
- Perception of pesticide hazard (harmful) exerted positive influence on PPE use.
- Old age exerted a significant negative influence on PPE use.

GRAPHICAL ABSTRACT



Use of PPE among farmers.

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ABSTRACT

Understanding factors affecting the use of personal protective equipment (PPE) during handling of plant protection products (PPPs) is of major importance for the design of tailored interventions to minimize exposure among farmers. However, data regarding this issue are highly limited. Factors related to the use of PPE during handling of PPPs were explored in a survey of cotton farmers in northern Greece. Data were collected through face-to-face interviews with the farmers based on a questionnaire with structured items on the frequency of use of various personal protective devices during handling of PPPs. New evidence on patterns of PPE use and potential exposure of farmers to PPPs is provided. Most farmers (49.3%) showed potentially unsafe behaviour with respect to PPE use. Hat and boots were the most commonly used protective items during PPPs use, but most of the farmers surveyed reported low frequency of use for gloves, goggles, face mask, coveralls, and respirator. Especially the respirator was reported to be the least used PPE item amongst farmers. Farmers who perceived PPPs as harmful substances or those who had an episode of intoxication in the past reported more frequent use of several PPE items. Stepwise multiple regression analysis revealed that the variable episode of intoxication in the past exerted the strongest positive influence on PPE use, followed by the perception of PPPs being hazardous substances, upper secondary education, previous training on PPPs (i.e., spraying equipment, application parameters, risks to human health and environment, safety issues) and farm size under cultivation. Old age exerted a significant negative influence on PPE use, namely, elderly farmers tended not to use PPE. Strategies to maximize the protection of applicators of PPPs from hazardous exposures still require innovation to achieve increased effectiveness.

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Emphasis on lifelong training and education of farmers about hazards and risks of PPPs is crucial for changing wrong behaviours in handling of PPPs.

1. Introduction

Plant protection products (PPPs) are widely used in agricultural production to control harmful pests, diseases, weeds, and other plant pathogens in an effort to reduce or eliminate yield losses and maintain high product quality (Damalas and Eleftherohorinos, 2011). However, as much as these chemicals are vital for ensuring safety in food production and thus also supporting economic growth, incorrect and indiscriminate use at all stages of handling can generate serious risks for human health and the environment (Calliera et al., 2013). Mishandling of PPPs poses serious health problems for farmers, especially, but not only, in developing countries. PPPs use could entail a high risk to human health while being beneficial to crops, depending on numerous factors that determine the levels to which exposure occurs (Damalas, 2009). The potential of having severe adverse effects on farmers' health is not due to intensive farming where PPPs are required to achieve a high yield, but due to the ignorance of farmers on the potential health effects implicated with the use of PPPs (Palis et al., 2006). Farmers are often unaware of the potential negative effects of PPPs on human health and may use excessive amounts of PPPs without adequate protective measures. Even farmers who are aware of the harmful effects of PPPs are often unable to translate this awareness into their practices (Damalas et al., 2006; Isin and Yildirim, 2007; Yuantari et al., 2015).

Farmers are routinely exposed to high levels of PPPs mainly during the preparation and application of the PPPs spray solutions, but also during cleaning the spraying equipment (Damalas and Koutroubas, 2016). Substantial dermal exposure of the operator during mixing and loading of PPPs, mostly in hands or the lower part of the body has been documented (Tsakirakis et al., 2010; Baldi et al., 2012; Gao et al., 2014; Cao et al., 2015). The use of PPE during PPPs handling should be a necessary part of working with agrochemicals. Various types of PPE can be used in PPPs handling to minimize dermal exposure. Although studies varied with regard to the types of chemicals investigated, the types of PPE examined, and the types of exposure measured, they clearly indicated that PPE is effective in reducing farmers' exposure to PPPs (Tsakirakis et al., 2010). Chemical-resistant gloves, boots, hats, long sleeve shirts, and certified coveralls are among the most common types of PPE (Damalas and Koutroubas, 2016). Reduction of farmers' exposure to PPPs may lead to lowering the incidence and severity of the adverse health effects related to their use. Therefore, it is vital to use reliable devices for personal protection.

The level of protection provided by a specific PPE item depends on the protective features of that particular PPE type, the means of PPPs application, and the level of proper fitting and maintenance by the farmers (Damalas and Koutroubas, 2016). Thus, the intended maximum levels of protection are seldom achieved in routine use of PPE and the actual level of personal protection is often difficult to assess. Studies concerning several PPE materials and designs lend further support to the effectiveness of PPE, although some of these studies also indicated variations due to fabrics and clothing design (Espanhol-Soares et al., 2013; Abirami and Selvakumar, 2014). Despite the fact that PPE use minimizes exposure to PPPs, several operator and worker exposure studies have shown that PPE is frequently not used (Damalas et al., 2006; MacFarlane et al., 2008; Damalas and Hashemi, 2010; Feola and Binder, 2010; Hashemi et al., 2012) or is used incorrectly (Singh and Gupta, 2009; Blanco-Muñoz and Lacasaña, 2011; Yuantari et al., 2015). Improvement of infrastructure and workplace conditions was found to be crucial for promoting safety practices and PPE use (Levesque et al., 2012).

When PPPs are the chosen method for pest control, it is important that the products are used properly to ensure efficacy in the field, personal and environmental safety, and also legal compliance. Poor knowledge and understanding of safety practices during PPPs use and erroneous beliefs about the necessity of PPE can seriously impair farmers' abilities to protect themselves against risks from PPPs use (Jørs et al., 2006; Zhang and Lu, 2007). Decisions on the use of PPE present a challenge for PPPs users. Many PPPs users are unaware of the potential hazards of PPPs use and often they are uninformed about the type of PPE that should be worn during PPPs handling. The use of personal protective devices depends much on individual decisions and these decisions can be influenced by various factors: risk perception, awareness of belonging to a risk group, awareness of the seriousness of potential hazards, belief that prevention is effective in reducing potential risk and also that prevention is possible (Damalas et al., 2006; Damalas and Hashemi, 2010).

Although much research has been carried out to describe safety practices with PPPs use, little is known about the use of PPE among end users. The need for further research into the relationship between risk perceptions and attitudes, and adoption of self-protective behaviours is often stressed (Remoundou et al., 2014). Such information is essential to know how farmers behave in PPPs handling in an effort to establish and assess prevention strategies that increase knowledge and aptitudes in this occupational group. To this end, information about farmers' perceptions and behaviours regarding safety practices during PPPs handling is essential. Therefore, understanding factors affecting the use of PPE during PPPs handling is of major importance, firstly for analyzing what behavioural drivers are relevant in that context and secondly for designing tailored interventions to minimize exposure to PPPs among farmers. Regretfully, data regarding this issue are highly limited. Thus, the objective of this project was to study the current levels of PPE use and the factors related to the PPE use among cotton farmers from rural areas in northern Greece.

2. Methods

2.1. Study area and sample selection

The study was carried out with 148 randomly selected farmers from rural areas of northern Pieria (Eginio and Methoni) in northern Greece. The survey consisted of interviews with farmers from areas where cotton is mainly cultivated. The selection of farmers was totally random based on the fact that prospective participants in the study included conventional cotton cropping over the last years in their farming activities and on the willingness of each farmer to participate in the study. Participants were individuals who were actively engaged in agriculture and directly involved in PPPs spraying. This was a necessary prerequisite for participation in the study. In general, the aim was to interview those who were most likely to identify the real situation in the field. This was achieved with the close cooperation and the assistance of the leaders of farmers' groups.

Cluster sampling (municipalities) with small subsets (villages) was used to collect data. Members of the subset can be more easily identified, contributing to lower costs of the survey (Green et al., 2006). Overall, 278 farmers were enlisted from lists of farmers obtained from the local farm supplies stores in each studied area. Potential participants were approached independently considering their availability and their willingness to participate in the study. The farmers gave oral consent to participate in the study after hearing a brief explanation of the

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