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Pesticide use and risk perceptions among farmers in the cotton belt of Punjab, Pakistan

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ABSTRACT

The need to evaluate pesticide use in rural populations, particularly in developing countries, is urgent. Pesticide use and related risk perceptions were studied among 318 randomly selected farmers from two areas of the cotton belt of Punjab, Pakistan. A total amount of 4875 kg of pesticide active ingredients was reported to be applied by the farmers per annum and most of these active ingredients were classified as moderately hazardous (55%) or highly hazardous (23%) according to WHO classification. The number of pesticide applications per growing season ranged from 6 to 16, with an average of 10 or 11 applications, depending on district. Better-educated farmers were found to spray less. Most farmers (52%) considered the risk from pesticide use to be low, whereas a solid fraction (12%) considered there was no risk at all. To model farmers' behavior on pesticide overuse, a binary probit regression model was used expressing behavior as a function of age, education, level of risk perception, health effects, pesticide toxicity class, and Integrated Pest Management (IPM) training. Irrespective of age, there was a clear tendency towards pesticide overuse, but the probability decreased with IPM training, a high level of education, and use of highly toxic pesticides. Awareness of the high toxicity of a pesticide product tended to discourage overuse. On the contrary, neither the experience of health effects nor the levels of risk perception affected overuse. Farmers were not well informed about correct application practices and safe handling of pesticides. Overall, findings affirm an urgent need for training programs on pesticide use in the study area with the aim of conveying more specific information on health hazards from pesticides that will avert hazardous behaviors of farmers derived from misleading beliefs about pesticide use.

1. Introduction

Pesticides are a significant component of the modern agricultural technology that has been widely adopted across the globe to prevent or control pests, diseases, weeds, and other plant pathogens in an effort to reduce or eliminate yield losses and maintain high product quality (Damalas, 2009; Damalas and Eleftherohorinos, 2011). Numerous major and minor benefits from pesticide use have been outlined, with the most pronounced being the economic benefits derived from the protection of commodity yield and quality and the reduction of other costly inputs such as labor and fuel (Cooper and Dobson, 2007; Damalas, 2009). Thus, like in other countries, a wide spectrum of pesticides is used on a large scale for the protection of crops in Pakistan. Actually, in the last twenty years there was an average growth of 11.6% in pesticide use in the whole country, but on the other hand, there was no major improvement in yields by this massive use of pesticides (Khan, 2010). The cotton crop, a cash crop with vital role in the country's economy, receives a large amount of pesticides, which accounts for more than 80% of the total use in Pakistan (Khan, 2009, 2011). There was almost a three-fold increase in pesticide use in this crop that gets the lion's share of pesticides, yet with disproportionately small improvements in yield (Khan et al., 2002).

Despite the numerous benefits of pesticides, the massive increase of pesticide use has led to a huge cost in terms of environmental and human health issues (Tariq et al., 2007). Research has shown that intense pesticides use is responsible for workers' poisonings, chronic diseases, and hundreds of fatalities in the country (Khan et al., 2002; Khan, 2010). Generally, national assessments of the health impacts of pesticide use are relatively rare; previous studies from the U.S. estimated that there were about 67,000 cases of pesticide poisoning annually (Pimentel, 1995) and the value of the external costs of pesticide use at over $2.5 billions (Tegtmeier and

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Duffy, 2004). However, many changes have been made regarding pesticide safety education and worker protection standards since then. A more recent study from the U.S. estimated that there were on average 20,116 cases of pesticide poisoning treated in health care facilities annually in the period from 2006 to 2010 (Langley and Mort, 2012). Pesticide use is also responsible for contamination of surface and ground waters in addition to increasing numbers of resistant pests in pesticides (Ahmad et al., 2001, 2002, 2007), a fact which in turn leads to high pest populations. In some cases, indiscriminate pesticide use causes severe degradation of agro-ecosystems through destruction of flora and fauna (Iqbal et al., 1997). Health issues usually arise because many farming communities are not adequately informed of the hazards associated with pesticide use in every-day practice (Salameh et al., 2004; Isin and Yildirim, 2007). Therefore, many farmers, particularly in the developing countries, overuse pesticides without taking appropriate safety precautions because they do not understand the risks and fear smaller harvests (Kishi, 2002; Yassin et al., 2002; Ntow et al., 2006; Recena et al., 2006; Rao et al., 2009; Khan, 2011; Stadlinger et al., 2011).

Several studies have identified overuse and misuse of pesticides in Pakistan under varying circumstances, especially in the cotton-growing areas of the country (Tariq et al., 2007). A research in the Sind district of Pakistan, which considered the efficient use of pesticides in cotton with respect to appropriate spray timing, discovered that farmers who were applying pesticides at rather inappropriate times (e.g. before and after the attack of pests) were getting reduced yield (Akhtar, 1985). Similarly, overuse of pesticides in cotton in the area of Punjab was reported, as the least efficient farmers were using 70% more pesticides to achieve the same level of yield as their counterparts (Khan et al., 2002). Other studies revealed that in cotton-growing areas of Pakistan the natural enemy pest populations declined up to 90% because of pesticide overuse in the period from 1990 to 2000 (Hasnain, 1999). As a consequence, this heavy use of pesticides has also imbalanced population of pests and their predators, which in turn increased the cost of pest control. In general, overuse of pesticides in Pakistan is typically expressed by spraying more times than required and using higher doses than recommended (Khan et al., 2002; Tariq et al., 2007; Khan, 2010). The overuse of pesticides occurs also in other south Asian countries (Dasgupta et al., 2005a, b; Rahman, 2013).

In light of the above evidence, serious concerns were raised with respect to the sustainability of farming in the country. There are clearly opportunities for more judicious pesticide use that would minimize both potential health problems and economic losses for farmers. However, as noted earlier, many farmers do not fully comply with recommended utilization practices for pesticides and they often use highly toxic pesticides in increased quantities to take advantage of the speedy action in an attempt to realize full control of pests (Dasgupta et al., 2005a; Tariq et al., 2007). To a certain extent, this attitude can be changed by providing education and relevant information to the farmers. However, information about risk perception and farmers' behavior in pesticide use is a prerequisite for any initiative for policy intervention. Information about perceptions of pesticide risk and exposure history among farmers is usually obtained via self-report information because farmers are self-employed and there are limited alternate sources of information regarding their exposure to pesticides (Hoppin et al., 2002). Additionally, the need to evaluate amounts of pesticides used by the rural population, particularly in the developing countries, is urgent. The objective of this research was to quantify the extent of pesticide overuse and also identify determinants of this behavior among farmers of the cotton belt of Punjab in Pakistan. This information can be useful in designing effective policies to address environmental issues and health problems due to pesticide overuse across the country.

2. Materials and methods

2.1. Study area

Two districts in the cotton belt of Punjab, Pakistan, i.e., Vehari and Lodhran, were selected for this study. Vehari district is spread over an area of 4364 km^2 and is subdivided into three tehsils (Burewala, Mailsi and Vehari). The district consists of a plain area, a part of Indus plain, with fertile land suitable for cotton, wheat, and other agricultural crops. Lodhran district is spread over an area of 1790 km^2 and is also subdivided into three tehsils (Lodhran, Kahror Pakka and Dunyapur). The basic economic sector of Lodhran district is agriculture with main agricultural production of cotton and wheat. These two districts have about 50 years of historical evidence of pesticide use and are well known for cotton production. These districts represent almost 17% of cotton growing area in Punjab.

2.2. Selection of sample

The study was carried out with 318 farmers who were randomly selected from the two districts of Punjab in 2008. The technique of multi-stage cluster sampling was used to obtain cross-sectional data in which larger clusters are further subdivided into smaller, more targeted groups for the purposes of the survey. Multi-stage sampling can create a more representative sample of the population than a single sampling technique and can help reduce costs of large-scale survey research (Green et al., 2006). Thus, it is often preferred for reasons of precision and economy. In this respect, as a sampling strategy after selection of study districts, all three tehsils from both districts were chosen for the survey as the representative area. Initially, a random sample of 400 farmers was drawn using an automatic random number generator. The overall response rate was 80%, so that finally 318 interviews were successfully completed. Of the remaining 20% of the names drawn, either some farmers were not available at the time of the interview or some others provided information not fully completed. Out of 318 sampled farmers, 149 farmers were from district Vehari and 169 farmers were from district Lodhran (Table 1). All farmers who were included in the sample were drawn from 30 villages (mouzas), i.e., 19 from Lodhran district and 11 from Vehari district. The selected villages in Lodhran were relatively smaller.

2.3. Data collection

To get information from the respondents, face-to-face interviews were carried out to fill a structured questionnaire. Although expensive, this method provides the highest response rates and is better suited to collecting complex information. The questionnaire was developed from previous World Bank studies in Vietnam and

Table 1
Distribution of sample population by district in the cotton belt of Punjab province, Pakistan.

District	Tehsil	Sample size	Total size
Vehari	Mailsi	55	149
	Burewala	52	
	Vehari	42	
Lodhran	Lodhran	54	169
	Dunyapur	66	
	Kahror Pakka	49	