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Perceptions of the beneficial and harmful effects of pesticides among Iranian rice farmers influence the adoption of biological control

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ABSTRACT

Perceptions of the pros (beneficial effects) and cons (harmful effects) of pesticides influence patterns of pesticide acceptance and use among farmers in developing countries. However, perceptions about pesticide effects can vary greatly among farmers and thus continuous research is always useful for developing effective intervention initiatives. A survey of 331 randomly selected rice farmers was carried out in Mazandaran province of northern Iran to study perceptions of the pros and cons of pesticides and to assess how these perceptions influence the adoption of biological control (BC) among farmers in the area. Most farmers were well aware of both pesticide effects, with slightly lower perception levels about pros than cons. The high risk of pesticides to human health was perceived as the most severe negative effect, whereas the boost of crop productivity with pesticides was the most frequent perceived beneficial effect. Although implementation of BC in the study area was quite low, most farmers expressed confidence in BC and were in favor of its adoption. High levels of education and a tendency for own consumption of produce were associated with high awareness of both pesticide effects among farmers. High income, high rice grain yields, and intense use of pesticides were associated with positive perceptions about pesticides, whereas high farming experience was associated with negative perceptions about pesticides. Perceptions of the pros and cons of pesticides could predict support or rejection of BC among farmers. Well-educated and experienced farmers, farmers with frequent extension contacts and high share of family labor force in farming activities, as well as farmers who recognized that pesticide use has cons were more likely to support BC in their farms.

1. Introduction

Rice is a staple food in Iran, often preferred over other cereals by most Iranian consumers (Rani, 1998). This crop is cultivated in several provinces, mostly in the northern parts of the country, and especially in the provinces of Mazandaran and Gilan (Rani, 1998). It is the crop with the highest pesticide inputs in Iran, given that insect pests and fungal diseases destroy a considerable proportion of the rice produced almost every year (Noorhosseini et al., 2010). Most of the losses are caused by the Asiatic rice borer or striped rice stem borer, *Chilo suppressalis* (Lepidoptera: Crambidae) (Salami and Khaledi, 2001). In Asia, this borer is responsible for a steady annual damage of 5–10% of the rice crop, with occasional localized outbreaks of up to 60% (Pathak and Khan, 1994). To reduce yield losses, farmers frequently apply higher rates of pesticides than those recommended by experts and extension agents, usually as a result of the common belief that the application of high pesticide rates is more effective. In this context, however, decisions on pesticide applications are made without consideration of human health and environmental concerns by many farmers (Allahyari et al., 2008).

During the last decades, agricultural production has undergone immense growth, relying heavily on external inputs, such as pesticides and inorganic fertilizers, as means of increasing food production (Tilman et al., 2002). Indeed, the use of pesticides boosted crop productivity and improved product quality, in terms of cosmetic appeal of fresh produce, but there are now concerns about overuse, mainly relating to contamination of water bodies, pesticide residues on food, and consequent negative effects both on

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wildlife and human health (Damalas, 2009; Damalas and Eleftherohorinos, 2011). Until 2009, the government of Iran supported the agricultural sector by increasing subsidies of farm inputs (fertilizers, pesticides, and fuel) and therefore farmers gained easy access to pesticides at low prices (Hashemi et al., 2012). Thus, chemical pest control with heavy use of pesticides was the rule for most farmers. To reduce the consequences of intensive agriculture in Mazandaran province of Iran, an integrated pest management (IPM) program focusing on biological control (BC) of pests with the use of natural enemies was firstly undertaken in rice in 1990 (Razzaghi-Borkhani et al., 2011). The program was based on *Trichogramma* spp. (Hymenoptera: Trichogrammatidae) that parasitize the eggs of moths (Lepidoptera), including the Asiatic rice borer. Parasitism and predation of rice borer eggs were important regulating factors of the population so that up to 80% control of this species could be achieved with the release of *Trichogramma* spp. in rice paddies (Rani, 1998). According to local officers in the area, most small-scale farmers after 2012 tend to use BC as an alternative to pesticides because parasitoid agents for BC are provided free by the government through the extension services of District Agricultural Office. Despite the fact that *Trichogramma* spp. can effectively control the Asiatic rice borer, many farmers kept spraying excessive amounts of pesticides due to poor knowledge of biological strategies of pest control and also due to lack of knowledge about potential risks of pesticides on human health and on the environment.

Numerous studies have examined farmers' awareness of pesticide effects on human health and on the environment and the levels of awareness varied considerably from one region to another (Parveen et al., 2003; Salameh et al., 2004; Damalas et al., 2006a,b; Atreya, 2007; Isin and Yildirim, 2007; Karunamoorthi et al., 2011; Mohanty et al., 2013). Because typically farmers are the main users of pesticides, the degree of awareness about pesticide effects inherently influences their methods of pest management. Perceived pros (beneficial effects) and cons (harmful effects) of pesticides or perceived needs of farmers were main determinants of implementation of alternative methods of pest control in previous studies (Nathaniels et al., 2003; Hashemi and Damalas, 2011). For example, farmers who considered that pesticides are harmful to the environment and human health were more concerned by the negative effects and were found to be more reluctant to use pesticides in their pest control practices (Rahman, 2003a). Moreover, cases of pesticide poisoning push farmers to change their behavior away from pesticides and search for alternative methods of pest control. Farmers who experienced health problems from pesticide use showed heightened concern about adverse health effects by pesticides (Lichtenberg and Zimmerman, 1999; Hashemi et al., 2012). Thus, knowledge of farmers' perceptions of pesticide effects may help in prediction of their behavior regarding pest control.

Farmers' knowledge of the pros and cons of pesticides can be influenced by several socio-economic characteristics, but apart from socio-economic characteristics, farm characteristics are also related to the level of knowledge and ultimately reflect decision-making regarding pest control strategies and attitudes towards pesticide use (Parveen et al., 2003; Rahman, 2003a; Isin and Yildirim, 2007). Farmers' awareness is often influenced by socio-economic characteristics, such as formal education and level of technical knowledge regarding pesticide use (Salameh et al., 2004; Khan et al., 2015). At the same time, decisions about pest control are quite subjective and may depend on several characteristics of farmers, including personal beliefs, perceptions, and preferences (Grieshop et al., 1988; Damalas and Hashemi, 2010; Hashemi and Damalas, 2011; Hashemi et al., 2012). Farmers' willingness to support a method of BC as one approach of IPM is normally based on the evaluation of the cost-benefit analysis compared with pesticides as alternative actions. In fact, farmers are often hesitant to support BC, unless they are sufficiently aware of the effects of pesticide use. Thus, identifying farmers' perceptions and awareness of pesticide effects is critical.

The aim of this research was to study farmers' perceptions of pesticide effects and the influence of these perceptions on the selection of pest management strategies among Iranian rice farmers. To this end, four related research questions were set for this study: (i) whether farmers are aware of the pros and cons of pesticide use, (ii) whether farmers support the adoption of BC, (iii) whether farmers' characteristics and farm characteristics can explain the perceived pros and cons of pesticides, and (iv) which variables (if any) are associated with support or rejection of BC. To the best of our knowledge, these four issues have not been examined together by past research and therefore are worthy of consideration.

2. Materials and methods

2.1. Study area

The study area was confined to the county Sari of Mazandaran province in the north part of Iran (Fig. 1). Mazandaran province is one of the most important agricultural areas in Iran. Recently, it has been reported as one of the three provinces with the highest volume of crop production in the country. The main crops grown in the province are: rice (the major rice-producing area of Iran), wheat, barley, fruits, and cotton. The total area under cultivation is 435,436 ha, almost 50% of which is covered by paddy rice according to Mazandaran Agri-Jihad Organization (MAJO, 2013). Regarding rice yield losses due to pests, the province experiences severe yields losses by several pests and diseases, especially due to the Asiatic rice borer (Salami and Khaledi, 2001). The surveyed areas were selected for the study because farmers in these regions are familiar with pesticides due to their constant involvement and long experience in chemical pest control. The majority of small-scale farmers in the area rely on synthetic pesticides to control pests, and especially to combat the number one pest problem in the area, the Asiatic stem borer.

2.2. Selection of sample

The target population for this study was all rice growers in Sari county of Mazandaran province. According to statistics of MAJO (2013), the total number of rice growers in the survey area was 5,060. From this statistic, the number of rice growers for the survey was calculated to 357 farmers using the following equation (Bartlett et al., 2001):

$$n = \frac{\frac{Z_{\frac{\alpha}{2}}^2 pq}{d^2}}{1 + \frac{1}{N}\left[\frac{Z_{\frac{\alpha}{2}}^2 pq}{d^2} - 1\right]}$$

Where n = sample size, N = population size (in this case N = 5,060 farmers), p = estimated proportion of the population (p = 0.5), q = (1 − p) (i.e., q = 0.5), d = one half of the desired interval width (d = 0.05), and z = the value from the standard normal distribution for the selected confidence level of 95% (z = 1.96).

The county of Sari is composed of six districts which are subdivided into 16 sub-districts. The central district was purposively selected for the study because it has the largest number of rice farmers in the county and is known for high (probably the highest) levels of pesticide use. Additionally, most biological control projects