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Analysis of pesticide application and applicator's training level in greenhouse farms in Galicia, Spain

S. Lamosa Quinteiro^{}, M. F. Marey Pérez,
C. Cabaleiro Sobrino, M. Barrasa Rioja*

Abstract

The aim of this paper is to determine whether training level affects the safe use of pesticides amongst pesticide applicators of Galician greenhouse farms (Spain). The relationship between pesticide applicator training and safe use of pesticides was statistically analyzed using non-parametric tests. Results did not reveal any relationship between the training level of pesticide applicators and the implementation of good practices in pesticide use. This paper questions current training systems for pesticide application and points to the need for the implementation of methods that assess and monitor the results and added value of training to pesticide applicators' practices.

Keywords: *Training, safe use, pesticides, pesticide applicator, non-parametric test*

Introduction

Intensification of agriculture around the world has led to an increase in the use of pesticides. Many authors have studied the health and environmental effects and consequences of the use of pesticides at the global and regional level (Ecobichon, 2001; Kishi and Ladou, 2001; Ergonen *et al.*, 2005; Chelme-Ayala *et al.*, 2008; Buchanan *et al.*, 2009).

According to some authors, farmers are aware of the health and environmental effects of the use of pesticides in agriculture despite their low level of education or specific training in pesticides (Recena *et al.*, 2006; Atreya, 2007; Zhang and Lu, 2007). Pesticide hazard awareness encourages farmers to: 1) use less toxic pesticides (FFTC, 2004), 2) increase the use of personal protective equipment (PPE) (Perry and Layde, 2003), 3) create an awareness on the potential danger of indiscriminate use of pesticides (Mandel *et al.*, 2000), 4) improve safe storage of pesticides (Bury *et al.*, 2005), 5) reduce expenditure on pesticides (Yamazaki and Resosudarmo, 2008), 6) increase crop yield (van den Berg, 2004), and, in general, 7) increase the safety measures taken by farmers (Salameh *et al.*, 2004; Atreya, 2007; Sam *et al.*, 2008).

Yet, the analysis conducted by Damalas *et al.* (2008) in Greece revealed the existence of poor practices among farmers, such as inappropriate disposal of pesticide packages, leftover spray solution or rinsates generated from washing the application equipment. Other authors verified a low use of personal protective equipment during pesti-

^{*} Department of Crop Production, Escola Politécnica Superior.
Universidade de Santiago de Compostela, Campus Universitario de Lugo. 27002 Lugo, Spain
telfs. 00 34 982 823 111, 00 34 609 591 013, e-mail santiago.lamosa@usc.es

cide handling (Zhang and Lu, 2007; MacFarlane *et al.*, 2008) and low levels of reading and understanding of pesticide labels (Avory and Coggon, 1994; Waichman *et al.*, 2007).

Pesticide applicator training is considered one of the most relevant aspects in the reduction of pesticide exposure and, consequently, of intoxications, as well as in the improvement of pesticide handling safety. Many authors have observed that training leads pesticide applicators to: 1) an improvement in diffusion of knowledge and integrated pest management (Feder *et al.*, 2004a; Feder *et al.*, 2004b; Hashemi *et al.*, 2008; Yang *et al.*, 2008; Hashemi *et al.*, 2009), 2) an increase in safe use of pesticides (Winstead, 1993; Mandel *et al.*, 2000; Sam *et al.*, 2008; Yamazaki and Resosudarmo, 2008) and 3) a reduction in the use of pesticides (Matthews, 2008; Mancini *et al.*, 2009). Moreover, Matthews (2008) verified that training caused increased crop yield, while Mancini *et al.* (2009) reported a positive effect of training on the decrease in the number of intoxication events, and MacFarlane *et al.* (2008) concluded that training increased the use of personal protective equipment.

Despite the positive effects mentioned in the above paragraph, some authors did not find a definite effect of training on the implementation of good handling practices by pesticide applicators. For example, Prochaska (1998) analyzed a population of Ohio Certified Private Pesticide Applicators and found no significant differences between level of education and reading pesticide labels. Feder *et al.* (2004a; b) did not find any improvement in farming activities among farmers who had attended the Farmer Field School (FFS), whereas Yamazaki and Resosudarmo (2008) reported an improvement in agricultural practices among farmers who had attended training courses, but verified that improvements decreased considerably over time. Moreover, other authors have found that knowledge is not transferred between pesticide applicators who have been trained and those of their neighbours who have not been trained (Feder *et al.*, 2004a; Tripp *et al.*, 2005; Hashemi *et al.*, 2008; Yang *et al.*, 2008; Hashemi *et al.*, 2009).

European and Spanish legislation regulating the use of pesticides, as well as Spanish Order 43/2002 of 20th of November governing Plant Health (BOE, 2002), enforce pesticide handlers and applicators to take training courses or exams that certify and ensure that they meet minimum training standards. In Spain, the requirements for getting a pesticide applicator license are regulated by Royal Decree 1311/2012 of 14th of September establishing the framework for action to achieve the sustainable use of plant protection products (BOE, 2012). The Galician legislation envisages six levels of certification: basic, qualified, fumigator, special certification for the application of toxic and very toxic pesticides to disinfect agricultural soils, special certification for the application of pesticides against micromammals in agricultural soils, and pest control aircraft pilot for agriculture and forestry (DOGA, 2009).

In this legal context, many farmers have taken training courses in the last decade. Actually, the number of farmers involved amounted to more than 2500 in specific years. Yet, this pesticide applicator training policy has not been monitored and its effectiveness has not been tested, such that the actual improvements in the practices of pesticide applicators remain unknown.

The objective of this study is to determine whether the training of the pesticide applicators affects the safe use of pesticides in greenhouse crops in Galicia, a region in Northwest Spain.

Materials and methods

A survey was conducted among greenhouse pesticide applicators in Galicia. According to data made available by the Galician Department of Rural Affairs, *Consellería de Medio Rural, Xunta de Galicia*, in 2009 there were 1260 farms specialized in indoor crops with an area equal to or over 500 m² in this region. The mean area of these farms was 1932 m² per farm.

This paper focuses on farms specialized in indoor crops because pesticide applicators are most exposed in this type of farms, insofar as applications are more frequent than in open-air fields, environmental conditions are extreme (high temperature and relative humidity), and ventilation is poor in partially-closed spaces.

The stratifying variable was selected based on the criteria defined by ASPROGA (2001), which suggest farm area as the variable with the strongest influence on the differentiation of farm management and crop yield per unit. Based on farm area, four types of strata were defined (Table 1). To calculate sample size, a single-stage stratified sampling strategy was used, and an error of 5% at 95% confidence level was assumed (Dalenius and Hodges, 1959), which provided a sample size of 301 pesticide applicators, which accounted for 23.9 % of greenhouse farmers. The final distribution of surveys across the region was randomly determined by defining a proportion of farms based on the area covered by greenhouse farms in each province. Table 1 shows the distribution of surveys according to the strata considered in the analysis and the representativity of the surveys.

Personal interviews with pesticide applicators were carried out (INE, 2009) between April and September 2009. First, applicators were contacted by telephone to arrange an appointment for a personal interview at their workplace. The questionnaire included 71 questions divided into 11 blocks.

Table 1. *Distribution of population and sampled farms by types (area of greenhouses) and provinces*

TYPE		PROVINCES								GALICIA	
		A CORUÑA		LUGO		OURENSE		PONTEVEDRA			
		POP	SA	POP	SA	POP	SA	POP	SA	POP	SA
E1	No.	169	31	24	4	96	11	292	50	581	96
	%	35.1	26.7	45.3	28.6	50.0	25.0	54.7	39.4	46.1	31.9
E2	No.	175	39	13	4	69	18	157	45	414	106
	%	36.4	33.6	24.5	28.6	35.9	40.9	29.4	35.4	32.9	35.2
E31	No.	109	37	11	5	27	15	72	30	219	87
	%	22.7	31.9	20.8	35.7	14.1	34.1	13.5	23.6	17.4	28.9
E32	No.	28	9	5	1	0	0	13	2	46	12
	%	5.8	7.8	9.4	7.1	0.0	0.0	2.4	1.6	3.6	4.0
TOT	No.	481	116	53	14	192	44	534	127	1260	301
	%	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

TYPE (by area of greenhouses): E1, 500 - 1000 m²; E2, 1000 - 2000 m²; E31, 2000 - 5000 m²; E32, >5000 m².

POP, population; SA, sample; TOT, total

The training level of the surveyed applicators was assessed through six questions:

- 1) time the respondent has been performing pesticide application activities,
- 2) general level of education,
- 3) specialized training in pesticides,
- 4) surface area of the greenhouse farm,
- 5) working time (part-time work, full-time work, etc.),
- 6) technical advice received. Answers to the questions were assigned values from 0 to 3, the most unfavourable answer being 0 and the best answer being 3.

All the questions were assigned the same weight, such that the value obtained for each pesticide applicator corresponded to the sum of the answers to the six questions. Based on the scores obtained, the pesticide applicators of the analyzed farms were grouped into three groups according to training level as follows:

- 1) high (≥ 12),
- 2) medium ($> 9, < 12$),
- 3) low (≤ 9).

This classification results from rescaling the scores from 0 to 10. Thus, a value of 9 corresponds to 5.0. Respondents under a score of 5.0 were considered to be insufficiently qualified. Scores between 9 and 12 (5.0-6.5) correspond to pesticide applicators with minimum qualification, and scores over 12 (6.5-10.0) correspond to the group of highly qualified pesticide applicators.

Good practices in pesticide use and application were evaluated through 25 questions classified into six blocks of identical weight. The answers to each question were assigned a value between 0 and 3, 0 being the value of the most unfavourable question and 3 the value of the best response. Each block was assessed by calculating the mean value of the answers to the questions included in the block. The final score was obtained by adding the values obtained for each block.

To analyze the correlation between the level of qualification of the surveyed pesticide applicators and the implementation of good practices in pesticide application, analyses were carried out using the Kruskal–Wallis test (Kruskal and Wallis, 1952) and the U-Mann-Whitney test (Corder and Foreman, 2009), followed by a testing procedure analogous to the Bonferroni pairwise comparison procedure, as described in Neter *et al.* (1996). These techniques are commonly used to differentiate situations (Kragten and Snoo, 2008). The R.2.10.1 software was used for statistical analysis (R Development Core Team, 2008). The method developed in this paper has been widely used in this type of survey (Litchfield, 2005; Dasgupta *et al.*, 2007; Zyoud *et al.*, 2010).

Results

Overall, the pesticide applicators interviewed in this study show a very homogeneous profile, with 92.1% having primary education qualification and 7.9% having no education qualification at all.

The rank-based analysis of the characteristics of the pesticide applicators surveyed in this study reveals that the applicator with a high level of qualification (score ≥ 12 points) show the highest levels of general and specific training and own the farms included mainly in strata E31 and E32. Moreover, pesticide applicators with a high level of qualification are the most experienced applicators (only 16.7% have less than 10 years experience) and are engaged in agriculture full-time or belong to cooperatives or agricul-

tural processing companies. In addition, 97.4% of these farmers have received technical advice (Table 2).

Table 2. *Main characteristics of the groups according to the level of qualification of pesticide applicators*

GROUP	High	Medium	Low
VALUE	≥ 12	$>9, <12$	≤ 9
TYPE	E31, E32	E2	E1
TRAINING	High	High	Medium
EXPERIENCE	High	Medium	Low
WORKING TIME	Full-time	Full-time	Full-time / Part-time
ASSOCIATIONS	High	High	Moderate
TECHNICAL ADVICE	High	High	Moderate

Pesticide applicators with a medium level of qualification ($9 < \text{score} < 12$) have basic levels of general education (73.8% have primary education qualification) or specific training (92.1% have attended a basic course on pesticide handling), own greenhouse farms included mainly in stratum E2, and are mid-experienced applicators (28.6% have less than 10 years experience). These pesticide applicators are usually engaged in agriculture full-time and receive technical advice (95.2%).

Pesticide applicators with a low level of qualification ($\text{score} \leq 9$) show low levels of general education (18.0% have no education qualification) or specific training (22.0% did not attend any training course), own greenhouse farms included mainly in stratum E1 and are the least experienced farmers (39.0% have less than 10 years experience). Most pesticide applicators in this group are engaged in agriculture full-time, but 27.1% of the applicators with a low level of qualification are engaged in agriculture only part-time. In addition, only 51.2% of these applicators have received technical advice.

Table 3. *Results of non-parametric tests for training groups*

TRAINING GROUP	N	Rank	Mean	df	As. sig.	Chi-square
Good practices	1	98	137.40	2	0.169	3.560
	2	126	157.01			
	3	77	158.47			
	Total	301				

N: Training group; Rank: number of items in group

Does the training level of workers have any correlation with the implementation of good practices in the application of pesticides? As shown in table 3, the non-parametric test does not find any correlation between both variables. According to these results, higher levels of qualification do not result in better practices in pesticide handling.

Discussion

Results suggest that there is no correlation between training level and the implementation of good pesticide application practices, which contrasts with the results reported by other authors, who have verified that both general education and specific training have positive effects on various aspects of agriculture in general and specifically on pesticide handling, insofar as training increases awareness of the consequences of irrational use of pesticides on health (Mancini *et al.*, 2005; 2009). Yet, our results are in agreement with the results reported by other authors who did not find any beneficial effects of training on aspects such as reading pesticide labels (Prochaska, 1998), improving the professional activity after taking professional certification courses (Feder *et al.*, 2004a; b) or sustaining the good practices over time (Yamazaki and Resosudarmo, 2008).

In our study, the differences found in the positive effects of pesticide applicator training are probably associated with the level of education of the populations studied. For example, in the analysis performed by Atreya (2007), the percent of surveyed farmers with a primary education qualification amounted to 38.2%, while 61.8% did not have any qualification. On the contrary, the population analyzed in this study shows a very homogeneous profile. Such a homogeneity can be the cause for the small influence of level of education and specific training on pesticide application habits.

Most of the authors cited above analyzed the situation in developing countries, whose population is characterized by a low level of education. In this study, the level of education and/or training of pesticide applicators is reasonably high, such that the improvements attained can be more subtle or even not perceived, as suggested by Mandel *et al.* (2000), who observed modest improvements in the use of individual protective equipment within a group of Minnesota farmers aged 40 years and older who received specific training. In that case, 82.8% of the population were high school graduates and 17.2% did not have such a qualification.

Based on the literature review conducted, we have observed that the efficiency of improvements in pesticide applicator training and training activities may increase with the decrease in the degree of development of the country and in the general education of the population.

Another characteristic that might have affected the results is the fact that the population surveyed is old and highly experienced, particularly if compared with other surveys carried out in less developed countries. In the analysis conducted in Nepal by Atreya (2007), 46.1% of the population was less than 31 years old and only 4.9% was older than 50, while in the analysis performed in India by Mancini *et al.* (2009), 34.4% was younger than 30 years and 7.7% was older than 50. Conversely, in the population surveyed in our study, 43.3% of pesticide applicators were older than 50 and 4.2% were younger than 30, which is indicative of the gradual ageing undergone by Spanish and European farmers, with 4.5 % and 1.8% of their population younger than 35 years, respectively (ASAJA, 2010).

Because attendance to professional training courses reduces concern about issues related to safe use of pesticides (Yamazaki and Resosudarmo, 2008), the high training level of the surveyed pesticide applicators must not reassure the authorities who are in charge of pesticide applicator training. Such a decrease in farmers' concern becomes

more serious in the Spanish context, given that Spanish legislation compels farmers who must apply pesticides to obtain a certified qualification as pesticide applicators (BOE, 2005). This compulsory measure does not envisage the personal motivations of farmers and, consequently, the measure does not imply greater training efficiency.

Conclusions

Our results suggest that in Galicia, a higher level of education and/or training of pesticide applicators does not result in better practices in pesticide application and handling.

The high level of training and experience of Galician pesticide applicators and the compulsory nature of specialization courses may be the reasons behind the lack of the expected positive effects of training on the practices of Galician pesticide applicators.

Policy makers should create new models of specific training to promote the voluntary participation of farmers and their motivation about these issues. Moreover, new models for the evaluation and control of results must be developed to determine the actual effectiveness of specialization courses.

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