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Do farmers adopt IPM for health reasons? – The case of Nicaraguan vegetable growers

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Abstract

Integrated Pest Management (IPM) has been promoted in developing countries because it is considered to increase productivity in a sustainable and environmentally friendly way. Ideally, the use of non-chemical methods of pest control allows farmers to reduce pesticide use, leading to a reduction in health risks from pesticides. Such health benefit could provide a major incentive for farmers to adopt IPM.

This paper investigates the impact of farmers' experiences and perceptions of health risks of pesticides on the adoption of IPM practices and pesticide use among small-scale vegetable farmers in Nicaragua.

Two levels are considered in the adoption process: (1) the testing and experimenting of farmers with IPM practices and (2) their use as a component of their crop management package. During the testing phase, farmers observe the effectiveness of the IPM practices. Based on their assessment they decide to adopt or not.

In this paper adoption is measured as a count of practices a farmer has tested and/or adopted. Poisson regression is used to model the number of practices tested used by the farmers as a function of experiences with poisoning, perceptions of health risks of pesticides and socio-economic farmer characteristics. Pesticide use in vegetable crops is analyzed using a linear regression model. Dummy variables for the use of selected IPM practices are included in order to analyze the effect of the adoption of IPM practices on pesticide use.

Results show that previous experience with pesticide poisoning incidents has a significant positive effect on the number of IPM practices tested by a farmer, but not on the adoption. Farmers who pay wage premiums to workers for the application of pesticides test and adopt more practices. Further significant factors are school education, characteristics of a cropping system and whether or not farmers had attended training in IPM. Pesticide use in cabbage production is reduced for the use of some of the considered IPM practices. However no significant effects of IPM practices on pesticide use could be demonstrated in other vegetable crops.

It is concluded, that experience of pesticide poisoning leads farmers to change their behavior and search for alternative pest control options, resulting in increased testing of IPM practices. For the decision to adopt these practices and for the level of pesticide use, other factors are important.

Introduction

This study is motivated by the fact that pesticides continue to be a major health risk for farmers in developing countries. Since Jeyaratnam et al. (1987) estimated that 5-7% of farmers in developing countries are victims of acute pesticide poisoning every year, this figure has been confirmed in different studies around the world (Kishi et al. 1995; Ajayi 2000; PAHO 2002; Labarta and Swinton 2005). Many efforts to reduce health risks from pesticides in developing countries have shown little effects, e.g. projects promoting the use of personal protective devices during spraying often have short term effects only (Atkin and Leisinger 2000).

Integrated Pest Management (IPM) has been promoted in developing countries because it is considered to increase productivity in a sustainable and environmentally friendly way. In IPM, knowledge is an important factor to manage the crop and crop environment in a way such that the use of external input, especially pesticides can be significantly reduced. So far, this technology has been developed and evaluated mostly focusing on the productivity and cost effects. Yet, studies about the adoption of IPM showed that these effects might not be the only factors in the use of the technology.

Different studies showed that farmers in developing countries are aware of pesticide health risks (Garming et al. 2006; Ntow et al. 2006). The question, whether farmers' perceptions of health risks influence adoption of IPM was addressed so far in two studies, with opposite results: For Nicaraguan bean growers, Labarta and Swinton (2005) found some evidence that farmers' prior experience with pesticide poisoning symptoms reduced the demand for pesticides and increased the adoption of different IPM practices. On the other hand, results from a study on IPM in cotton in Zimbabwe Maumbe and Swinton (2000) showed no significant impact of attitudes towards health on adoption of IPM.

These studies focus on analyzing the adoption of IPM as observed in the actual cropping cycle in one step. However, Rogers (2003) describes the adoption of a new technology as a process of information, experimentation, decision, implementation and evaluation. Different factors may influence the adoption process at its different stages. Dimara et al. (2003), in their case study on organic farming in Greece propose to consider at least two stages in the process of adoption, the awareness and the adoption stage. In the case of the adoption of IPM practices, the testing of practices can be assumed to be a crucial stage before the decision on adoption is made. Simple adoption models may fail to identify the factors that influence decision making during these two stages in the learning and adoption process.

This paper investigates the impact of farmers' experiences and perceptions of health risks of pesticides in the adoption process of IPM practices and on pesticide use among small-scale vegetable farmers in Nicaragua, considering two levels of adoption: the testing of IPM practices and the adoption.

The objective is to assess the overall question of the relationship between farmers' perceptions of pesticide health risks and their choices with regard to pest control. Hence this study contributes to understanding the incentives for using pesticides and alternative pest control practices and hence to designing policies in order to reduce pesticide poisoning.

The Model

Based on household theory, the driving force for the adoption of new technologies is assumed to be farmers' gain in utility, which is often equated with profit. Therefore, a simple household production model is considered with utility expressed as a function of agricultural output Q providing income to purchase desired market goods and health status H, which is a non-market good. If a new technology is adopted benefits are expected either with respect to agricultural output or health status. For a pesticide-saving technology, the health status will be higher for the same level of output; hence health can be assumed to be a factor in farmers' choice of pest control technology.

The analysis proceeds in two steps. First the factors that make farmers to experiment and adopt IPM practices are identified and thereafter the effect of IPM adoption on farmer health is explored.

To answer the first question it is necessary to define IPM. This is difficult because the use of IPM practices is highly situation-specific. Hence it is difficult to judge its relative importance. Therefore, a frequently used measure of IPM adoption is to count the number of practices out of a set of typical practices (Maumbe and Swinton 2000; Ramirez 2000). This assumes that more practices used by the farmer imply a higher level of IPM adoption. In our study the set of IPM practices contains 11 different practices defined based on consultation with national experts [1]. Two levels of adoption are considered for each practice: the experimentation level, at which the farmer had ever tested the practice and the adoption level, if he is actually using it.

The count of IPM practices used can take on only integer and nonnegative values including zero. For this type of data, Poisson regression models are commonly applied (Wooldridge, 2006) #554}{Cameron, 1998 #443}. Hence, for analyzing the effect farmers' experiences with and perceptions about pesticide-related health on the two levels of adoption two Poisson regression models were fitted with the dependent variable being a) the count of practices tested by a farmer and b) the count of practices actually used by the farmer.
Therefore, the count of practices y_i is assumed to be Poisson distributed and the probability that a farmer uses a certain number of practices Y_i on his farm can be expressed as:

$$\Pr ob(Yi = y_i) = \frac{e^{-\mu_i}\mu_i^{y_i}}{y_i!} \ ; \ y_i = 0,1,2,...11 \qquad \text{(i)}$$

The conditional mean of the count μ_i is equal to the variance of the distribution and depends on a vector of explaining variables x_i.

$$E(y_i|x_i) = Var(y_i|x_i) = \mu_i = \exp(x_i\beta') \qquad \text{(ii)}$$

Explanatory variables include socio-economic farmer characteristics, information sources of the farmer, the portfolio of crops grown and health related variables. The latter are dummy variables on the farmer's previous experience with pesticide poisoning, whether he pays wage premiums for pesticide application to hired laborers and whether the farmer himself or some one else usually does the spraying.
In a second step, the effect of IPM practices on health risks from pesticides is investigated. As proxy the amount of pesticides used can be used. A more precise measure however is the shift towards pesticides with lower human toxicity. A linear regression model is used to analyze the effect of IPM adoption on the quantity of pesticide use and on the share of hazardous compounds out of the total amount used by the farmers. This share should be small, if a farmer shifts to less toxic pesticides when adopting IPM practices. Hazardous pesticides are defined as those classified by the WHO as extremely, highly or moderately hazardous, categories Ia, Ib and II respectively, as compared to the non-hazardous pesticides in WHO classification III, IV or U (WHO 2002). IPM adoption is specified as dummy variables for each of the practices, with 1 if the farmer is actually using the practice and 0 otherwise. Other explaining variables for pesticide use and the share of hazardous products are health related variables, and farmer characteristics. The farmer's expectation on yields and prices are assumed to be determinants of pesticide use as well. Gross income and the use of fertilizer are included as proxies. The pesticide use functions are estimated separately for different vegetable crops.

Data

The analysis is based on data from a survey among 430 small-scale vegetable farmers in four survey regions in Nicaragua. Farmers were interviewed using a structured questionnaire suitable

[1] The study was carried out in collaboration with the CATIE IPM programme, which developed IPM options for different crops and provided large scale farmer training.

to assess IPM knowledge and adoption, pesticide use and their profits in the previous cropping season, experience with pesticide-related health and household and farm characteristics.

The typical IPM practices in vegetable production include general management practices like crop rotation or the treatment of soil with lime, practices with a direct effect on a direct effect on pest populations like botanical pesticides, yellow sticky traps and agronomic practices to reduce pest pressure like nets to cover seedbeds or hedges to retain pests. The general management practices are most commonly used with up to 80% of farmers adopting crop rotation. Botanical pesticides or nets to cover seedbeds are much less used, probably because they require additional inputs and equipment. Also labor-intensive practices like the planting of hedgerows to retain pests and the use of trap crops that attract pests and prevent them from infesting the fields are rarely used. On average, a farmer has tested about 5 practices and uses between 3 to 4 of them.

The data show that the problem of pesticide poisoning is important for farmers, with a share of 5.3% of farmers having experienced acute poisoning in the survey year and a total of 26% that suffered poisoning at some point of time before the survey year. Poisoning symptoms like dizziness, sickness and vomits, skin or eye irritation related to pesticide application are reported frequently.

Results

The results of the Poisson models on two levels of adoption show that higher awareness of pesticide health risks leads farmers to test IPM practices (Table 1). The variables “prior experience of pesticide poisoning” and “paying extra benefits to workers for applying pesticides” have a significant impact on the number of IPM practices tested. There is a difference when the actual adoption is considered: Poisoning has no impact, however the variable “extra benefits” has. This variable may not only capture awareness of health risks, but also the additional costs of labor for spraying operations, which may represent a motivation to adopt alternative practices. Of the farmer characteristics, participation in IPM training has the expected positive sign for both levels of adoption. Education also positively influences the experimentation and adoption of IPM practices, as one would expect for a knowledge intensive technology like IPM. Respondents’ age is positively correlated with experimentation but not with adoption, which is plausible, since older farmers have had more time for experiments during their life as farmers.

Landowners are more likely to adopt alternative pest control than those who only rent the land, which may be related to the longer-term effects of IPM practices as compared to the immediate action of pesticides. With respect to the crops, leafy vegetables like cabbage and lettuce are those where IPM practices are most tested and adopted as compared to bulb vegetables and subsistence food grain production.

Table 1: Results of Poisson regression model, selected variables. [2]

Model	IPM_test		IPM_use	
	Coef.	Robust S.E.	Coef.	Robust S.E.
Const.	0,882	0,128 ***	0,833	0,103 ***
Farmer Characteristics				
Age	0,004	0,002 **		
Schooling	0,030	0,008 ***	0,023	0,010 **
Trained	0,375	0,046 ***	0,302	0,055 ***
Land owner			0,136	0,059 **
Experiences with Poisoning				
Intox before	0,091	0,049 *	0,077	0,055
Benefits	0,205	0,059 ***	0,134	0,066 **
Crops				
Leafy veg.	0,191	0,058 ***	0,188	0,065 ***
Bulb veg	-0,100	0,065	-0,153	0,075 **
Food grains	-0,087	0,047 *	-0,165	0,055 ***
Survey Regions				
Esteli	0,337	0,105 ***	0,340	0,116 ***
Jinotega	0,117	0,111	-0,024	0,121
Matagalpa	0,158	0,107	0,099	0,123

* significant at .1 level, ** significant at .05 level, *** signifant at .01 level
Source: own calculations

The models of pesticide use and share of hazardous pesticides were estimated for different crops. However, pesticide use can only be explained well for cabbage production, but not for the other crops. This could be related to the observation that the average amount of pesticides is 5 to 6 times lower in cabbage than in the fruit and bulb crops. However a technical comparison between the different crops is beyond the scope of this study.

In Table 2, the results for pesticide use in cabbage are presented. A number of IPM practices are significantly correlated with a reduction in the use of insecticides and also influence the share of hazardous pesticides on total pesticide use. The use of crop rotation and hedges to retain pests decreases the pest pressure in the crop and is negatively related to the amounts of insecticides used in cabbage. Also, the application of yellow sticky traps contributes to insecticide reduction. The use of leafy fertilizer, which is prepared on the farm in a fermentation process, is a practice that is typically used by the more advanced IPM farmers; hence its effect on pesticide use is also negative as expected. The application of lime however is correlated with higher amounts of insecticide use. This application has two main objectives, first, the control of soil-borne pests and diseases, which should reduce the use of the highly toxic insecticide Carbofuran and fungicides and second, to adjust soil acidity to enhance the uptake of nutrients and hence increase the effect of fertilizer application. The positive sign in the model could be explained by the latter function: fertilizer use also has a positive impact on pesticide use, reflecting a generally higher level of input use. The fact that neither lime use nor fertilizer has an effect on the share of hazardous pesticides can be used to support this explanation. Gross revenue has no impact on pesticide use. This is explained by the high variation of yields and prices in vegetable production, which are difficult for the farmers to predict at the time of pesticide applications. Hence, the amount of fertilizer used is a better proxy for the level of input use, reflecting a farmer’s expectations on yields and prices.

The model of the factors influencing the toxicity of products used in cabbage production, expressed as share of hazardous pesticides indicates that the adoption of IPM practices can have positive effects on farmer health: the same practices that lead to a reduction of insecticide use in general also reduce significantly the share of products that are hazardous to human health. The positive sign of the practice of using trap crops is puzzling. However, in cabbage, this practice is rarely used.

Interestingly, farmers' previous experience with poisoning and the variable of "paying wage premiums to hired labor" have no effect on the amount or types of pesticides used. A possible explanation is that farmers' concerns about health influence their choice of technology. However their degree of risk aversion makes them to maintain high levels of pesticide use.

Table 2: Linear Regression on insecticide use and share of hazardous pesticides in cabbage production [2]

	Insecticide use [kg/ha]		Share of hazardous pesticides	
	Coef.	t-value	Coef.	t-value
(Constant)	1,02	2,811 ***	0,309	2,503 **
Farmer characteristics				
Age of household head			0,007	3,324 ***
Schooling [years]			0,015	1,467
Fertilizer [kg/ha]	0,019	7,511 ***		
IPM practices [dummy]				
Leafy fertilizer	-1,156	-2,607 **		
Covered seedbeds	-0,517	-1,505	-0,182	-2,056 **
Lime application	0,676	2,676 ***	0,066	0,989
Crop rotation	-0,632	-1,952 *	-0,201	-2,280 **
Hedges to retain pests	-0,540	-2,223 **	-0,141	-2,253 **
Trap crops	0,847	1,675 *	0,278	2,277 **
Yellow traps	-0,611	-1,675 *	-0,189	-2,008 **
Fertilizer crops	0,997	2,161 **		
Adjusted Rsquare	43,7		19,3	

* significant at .1 level, ** significant at .05 level, *** signifant at .01 level
Source: own calculations

Conclusions

This study confirms that farmers are aware of the health risks of pesticides and search for alternatives to reduce them. These findings correspond to a positive willingness to pay to avoid health risks, found in a contingent valuation study in Nicaragua (GARMING and WAIBEL 2006). Most importantly past experience with pesticide poisoning seems to influence the behavior of Nicaraguan vegetable farmers and makes them more likely to experiment with and also adopt alternative pest control (IPM) practices. In the decision on actual adoption however, other variables are important and the experience of poisoning is not significant. The paper concludes that in the promotion of IPM health could be more effectively used as an argument stimulating farmers to finally also modify their pesticide use practices.

[2] Due to limited space only the statistically significant variables are presented here.

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