Tropentag 2010
ETH Zurich, September 14 - 16, 2010
Conference on International Research on Food Security, Natural Resource Management and Rural Development

Testing environmental and health pesticide use risk indicators. The case of potato production in Boyacá, Colombia.

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Introduction

Pesticide risk indicators are a relatively simple tool for the assessment of environmental and health risks from pesticide use. Based on the level of complexity of pesticide risk indicators, two broad typologies can be identified (Reus et al., 2002). The first includes user friendly assessment tools, usually with few input data requirements, and a scoring table based on rather simple algorithms which are often constructed on the basis of expert judgment. The second typology includes indicators using a risk-ratio, or exposure-toxicity ratio (ETR) approach, i.e. “the ratio between exposure (usually the concentration in a certain environmental compartment) and toxicity for relevant organisms” (Reus et al., 2002). These indicators are considered to better represent and quantify environmental risks from pesticide use, but have the drawbacks of requiring more detailed input data and the support of computer modelling (Reus et al., 2002). The extent to which simple and complex pesticide risk indicators provide convergent assessment results is an open issue.

The quest for simple but reliable assessment methods is particularly relevant in Less Developed Countries (LDC). Not only are LDCs often characterised by particularly serious pesticide-related externalities (e.g. Ecobichon, 2001), but also by a lack of resources dedicated to environmental protection and the promotion of sustainable agricultural production. However, one open issue in this regard is that pesticide risk indicators are usually developed for productive and pedoclimatic conditions in Western countries, which might imply an incorrect assessment of pesticide risks in LDCs. While comparative evaluations of pesticide risk indicators exist (e.g. Maud et al., 2001; Reus et al., 2002; Castoldi et al., 2007), they do not refer to the conditions of resource availability usually encountered in LDCs and neglect human health risk indicators.

The objective of this study was to investigate the appropriateness of seven ETR and non-ETR pesticide risk indicators for use at farm level in LDCs, with particular reference to smallholding agriculture in the Colombian Andean region.

Material and Methods

Seven farm-level indicators, i.e. EIQ (Kovach et al., 1992), PestScreen (Juraske et al., 2007), EPRIP (Trevisan et al., 2009), PIRI (Kookana et al., 2005), POCER (Vercruysse and Steurbaut, 2002), OHRI (Bergkvist, 2004) and the indicator proposed by Dosemeci et al., (2002) were selected so that i) every environmental and health compartment was considered by at least two of the selected indicators and ii) both simple, i.e. non-ETR, and complex, i.e. ETR, indicators were represented (Table 1). All indicators chosen present a relative outcome, i.e. the assessment provides a qualitative statement on the relative risks a pesticide application or control strategy might have in comparison to the application of another pesticide or to a control strategy based on different pesticides

Table 1. Risk indicators considered in this study by environmental and health compartments

		EIQ	PestScreen	POCER	EPRIP	PIRI	OHRI	Dosemeci et al. (2002)
Environment	Soil		*	*	*			
	Air		*		*			
	Surface water	*	*	*	*	*		
	Groudwater	*	*	*	*	*		
	Beneficial arthropods	*		*				
Health	Pesticide operator	*		*			*	*
	Farm worker	*		*				
	Consumer	*	*	*	*	*		
Calculation	ETR			*	*	*		
	Non-ETR	*	*				*	*

The data necessary to calculate the indicator rankings were mainly derived from an existing georeferenced dataset produced in a previous study in the *vereda* (community) called La Hoya, located in the Department of Boyacá, in the eastern chain of the Colombian Andes (Feola and Binder, 2010a and 2010b). The data consisted of detailed information on 72 farmers' safety practices (e.g. hygiene and use of personal protective equipment) and pesticide applications on one selected plot (potato crop) during one entire agricultural cycle (March to August 2007). Additional data necessary to calculate the indicators was mainly gathered from literature.

The study consisted of three phases. First, the indicator values were calculated for the pest control strategy and for single pesticide applications. A pest control strategy is defined for each of the 72 farmers on the basis of the total amount of pesticide applied by active ingredient.

Second, the indicator rankings were compared by means of the Spearman rank correlation test, in accordance with Maud et al. (2001) and Reus et al. (2002), and using the software PASW Statistics 18.0. Not only were the indicators compared with respect to their overall outcome, but also every individual environmental and health risk component that the indicators have in common (Table 1) was compared separately. Furthermore, the indicators were compared with regard to both the 518 pesticide applications and the 72 control strategies.

Third, a comparison based on key indicator characteristics was made, taking into account each indicator's usability (i.e. data availability, calculation procedure, and interpretation of ranking) and ability to represent the specific system under study (i.e. compartments considered, use of site specific data).

Results and Discussion

Simple versus complex pesticide risk indicators. Comparison of the indicators with regard to the total environmental risk suggests that simple indicators not relying on an ETR approach cannot be used as a reliable proxy for more complex indicators, i.e. those relying on an ETR approach. In effect, the values of the former (i.e. EIQ, PestScreen) tended to correlate weakly with those of the latter (i.e. EPRIP, POCER and PIRI) when the total environmental risk was considered (Feola et al., unpublished). When single compartments were considered, the correlation between the indicator rankings was stronger, which confirms the results of other studies (Maud et al., 2001; Reus et al., 2002). However, the correlations between non-ETR and ETR indicator values for single compartments were rather weak in the majority of cases (Feola et al., unpublished).

Concerning the human health risk, correlations between rankings of different indicators, both ETR and non-ETR, tended to be weak and to change significantly when the control strategies instead of the single applications were considered. These differences were very likely to depend on the radically different attribution of risk potential to different factors in the indicators, i.e. misuse of protective equipment and highly toxic pesticides in POCER, powder formulations and large plot areas in OHRI, misuse of personal protective equipment and hygiene habits in Dosemeci et al (2002). Since no other similar comparison of health pesticide risk indicators exists in the literature, it was not possible to compare these results with those of other studies. Further research in this direction is recommended.

Use of pesticide risk indicators in less developed countries. Recent developments of EPRIP (Trevisan et al., 2009), and in particular the provision of a freely accessible, user-friendly software with an internal database, have reduced the complexity of this indicator and made its use relatively simple. Moreover, EPRIP is also the indicator that more strictly complies with the other requirements identified by previous studies for the development of more accurate pesticide risk indicators (i.e. Maud et al., 2001; Reus et al., 2002). Therefore, among the indicators compared in the present study, EPRIP seems to best combine the need for a relatively simple tool to be used in contexts of scarce data availability and resources, and that of a more reliable estimation of environmental risk. Nevertheless, non-ETR indicators remain very useful and accessible tools for discriminating between different potentially risky pesticides prior to application. In this regard, PestScreen is probably to be preferred to EIQ for it not only includes halflife values for single media but makes use of the overall environmental persistence.

With regard to human health risk indicators, because of the uncertainties still existing in the literature on human exposure to pesticide, it might be preferable to avoid using indicators based on exposure models. In addition, these models are usually developed under European conditions, which can be very different from those observed in LDCs such as the study area (Feola and Binder 2010a and 2010b). In these contexts it might be less important to accurately quantify the exposure of farmers to pesticides than to understand the determinants of exposure, both in terms of risk factors (e.g. misuse of personal protective equipment, hygiene habits) and of determinants of risky behaviour (e.g. cost of protective equipment, social norm). Consequently, algorithms such as the OHRI or the indicator proposed by Dosemeci et al. (2002) would seem more appropriate in assessing human health risk in LDCs. However, these indicators might also suffer from a bias towards North American or European application. Further research on the validation of such parameters under the pesticide application conditions found in many LDCs is needed.

Conclusions and Outlook

This study investigated the appropriateness of seven pesticide risk indicators for use at farm level in Less Developed Countries, with particular reference to smallholding potato production in the Department of Boyacá (Colombian Andean region). The comparison of the indicators with regard to the total environmental risk suggests that simple indicators not relying on an exposure-toxicity ratio approach cannot be used as reliable proxies for more complex ones, i.e. indicators based on an exposure-toxicity ratio approach. The indicator EPRIP, which follows an exposure-toxicity ratio approach, seems to best combine the need for a relatively simple tool to be used in contexts of limited data availability and resources, such as those usually characterizing Less Developed Countries, and that of a reliable estimation of environmental risk. Indicators not based on an exposure-toxicity ratio approach such as PestScreen remain useful and accessible tools for discriminating between different pesticides prior to application. Concerning the human health risk, simple algorithms such as the OHRI or that proposed by Dosemeci et al. (2002) seem more appropriate than complex ones in assessing human health risk in Less Developed Countries. This study also pointed out the need for further research on health risk indicators and their validation under the conditions encountered in Less Developed Countries.

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