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Humans: the Neglected Corner of the Disease Tetrahedron - Developing a Training Guide for Resource-Poor Farmers to Control Potato Late Blight

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Abstract

Late blight, caused by *Phytophthora infestans*, continues to be one of the major threats to potato (*Solanum tuberosum)* production, especially in developing countries. Resistant cultivars and fungicides are the main tactics used to fight the disease, however, it was not clear which competencies resource-poor farmers needed to best control this disease. A competence is a "standardized requirement for an individual to properly perform a specific job, including a combination of knowledge, skills and behavior". This study describes how competence analysis was used to develop a training guide for extension workers in Ecuador. A group of farmers, extension workers and plant pathologists identified five competencies needed to manage late blight efficiently: i) capable of recognizing the symptoms of disease and know which organism causes it; ii) know how this organism lives; iii) identify the characteristics and benefits of using resistant potato cultivars; iv) use fungicides appropriately; and v) by periodically visiting the potato field, be able to select practices that control late blight efficiently. Mental abilities, physical skills, attitudes and information specific for each competence were identified and from those, learning objectives were defined. Based on the objectives, the contents for each training session were defined, after which learning strategies and evaluation questions were developed. A Spanish version of the training guide was developed and iteratively tested and improved in three farmer field schools in the central highlands of Ecuador. The guide was then published in Spanish, and subsequently translated to and published in Ecuadorian Quechua and English.

INTRODUCTION

One common characteristic of most resource-poor potato farmers in developing countries is that they know very little about the processes which cause plant disease. Farmers know much about biological entities they can see, such as crops and animals, less about insects -some stages of which they don't see- and almost nothing about microorganisms (Trutmann et al., 1993; Ortiz and Forbes, 2003). The common answers to the question of "what causes blight" will be anything but correct: lightening, low temperature, rain, sun while it rains, stages of the moon, bad seed, or mystical explanations (Ortiz and Forbes, 2003). Therefore, in spite of having access to new technologies, particularly ago-chemicals, many rural people have not gained new knowledge from agricultural science. For this reason, humans seem to be the neglected corner of the disease tetrahedron (Fig. 1).

The limited knowledge that resource-poor farmers have about pesticides, together with other factors that affect potato late blight (PLB), has led to an epidemic of pesticide poisonings and other chronic health problems in the developing world. The Food and Agriculture Organization (FAO) (Anonymous, 2003) produced an International Code of Conduct on the Distribution and Use of Pesticides. Based on this code, highly toxic pesticide (Class-I, WHO system) should be banned, because necessary protective clothing is cumbersome, expensive and almost never used (Eddleston et al., 2002; Wesseling et al., 2005). The most recent version of the code promotes corporate responsibility in pesticide trade, but we have not been able to find documented examples where the industry willingly removed hazardous pesticides from a market. A recent study has indicated that adherence to the code is very low in Peru and Ecuador (Orozco et al., 2009), and this is undoubtedly the case in most developing countries. While the majority of dangerous pesticides are not fungicides, three of the most commonly used late blight fungicides

(mancozeb, maneb and chorothalonil) were recently included in a list of pesticides considered to be dangerous to developing country farmers (Wesseling et al., 2005). The increasing number of technical and development workers decrying the current pesticide crises in developing countries concurs that in addition to effective regulation, integrated pest management and natural pest control methods are required.

The lack of knowledge about basic aspects of the disease itself makes it difficult to simply teach farmers how to manage fungicides or other technologies. For that reason, extension workers in developing countries have been using knowledge-intensive, participatory techniques to help farmers increase their understanding of how disease occurs and how it can be managed. The most commonly used participatory approach is probably the farmer field school (FFS). The International Potato Center (CIP) and partners initiated a FFS program in the late 1990s with support from the Food and Agriculture Organization of the United Nations (FAO) (Sherwood et al., 2000; Nelson et al., 2001).

To provide FFS facilitators with materials related to potato, a guide was developed by CIP and partners in Peru with a strong focus on PLB (Nelson et al., 2002). Initially, the FFS were intended to focus primarily on PLB, but this rapidly evolved into a focus on potato integrated pest management (IPM) and potato production in general in response to needs expressed by farmers. Subsequently, a number of other materials were developed in other countries, including Bolivia (Gandarillas et al., 2001), Ecuador (Pumisacho and Sherwood, 2000; Pumisacho and Sherwood, 2005) and El Salvador (Anonymous, 2000). All of these were focused on potato and contained some information and/or activities related to PLB management.

In 2006, CIP initiated a comparison of FFS guides dealing with PLB. Many commonalities were found and are discussed in more detail later. This work was initiated in part by a need expressed by FFS facilitators to produce more thorough materials for PLB management. It was assumed that a farmer-focused approach, which emphasized the capacities farmers need to manage the disease, would produce more balanced and thorough materials, which would have greater impact in the field.

This paper describes the process followed since 2006 that has resulted in the production of a new PLB guide for FFS facilitators (the users) who work with resource-poor farmers in developing countries (the beneficiaries). We also discuss some of the issues related to use of the guide and the general problem of building capacity of farmers for PLB management.

MATERIALS AND METHODS

The approach that was taken to develop the capacity building guide consisted of three stages described in the next paragraphs.

Collection and analysis of existing materials

Previously published materials related to building farmer capacity for PLB management in developing countries (Anonymous, 2000; Pumisacho and Sherwood, 2000; Gandarillas et al., 2001; Nelson et al., 2002; Pumisacho and Sherwood, 2005) were compared for content and methodology. A synthesis of the materials was developed to facilitate access for the following step.

Participatory workshop

A workshop was organized in February, 2006, in Quito, Ecuador in which 25 people participated. These included FFS facilitators, extension workers, and plant pathologists. In this workshop participants followed a methodology refined by V. Zapata which relies heavily on knowledge management theory (Zapata, 2006). The methodology consisted of: i) identification of the competencies farmers need to control PLB; ii) analysis and description of the components for capacity building; iii) development of the learning objectives; iv) selection of content and information sources; v) selection of strategies and resources, vi) identification of the facilitators functions; and vii) development of the evaluation questions.

The farmer competencies were identified by a participatory process in which the following concept was developed: "to effectively manage PLB, a famer needs to be capable of….." This was done by working in groups and then evaluated in plenary sessions. Once the competencies were identified, the participants identified the capacity building components, which were: mental abilities, physical skills, attitudes, and information. These components then gave rise to different learning objectives. For each component (e.g., mental ability) at least one learning objective was developed. Each objective had the same structure, consisting of a subject (to whom is the objective directed), verb (what is the nature of the action the subject will do), conditions (under which the subject does the action) and the criterion (used to evaluate the action). Special care was given to use verbs representing actions that later could be evaluated. For example, instead of using verbs like 'know' or 'understand', verbs such as 'describe' or 'draw' were used.

Guided by the learning objectives, the participants then identified the information that was needed as content to support the development of the abilities, skills and attitudes.

The content was found in a number of sources, including the previously published guides that had been synthesized, other pamphlets, books and Internet. The next step was to develop strategies to deliver the content to the end user. Here a number of existing participatory activities were evaluated and the best were included. In many cases, groups also developed new approaches to facilitate learning of particular capacities and knowledge.

The final part of the process involved defining the role of the facilitator. Here clear instructions were developed to assist facilitators in the implementation of the sessions. Questions were also developed that would guide the facilitator in the evaluation of success of the learning objectives.

Validation and publishing

The results of the process described above were formulated into modules using the guidance of experienced facilitators. The modules were then validated and iteratively improved in three FFSs in the central highlands of Ecuador (68 farmers; 49 men and 19 women) and in two workshops of facilitators, one in Peru (10 participants) and the other in Pyongyang, Democratic People's Republic of Korea (DPRK) (seven participants). Finally modules were assembled into a guide with appropriate technical design, and published.

RESULTS

Collection and analysis of existing materials

A total of 25 activities related to PLB management were compiled from the earlier sources. The sources varied but generally dealt with one or more of seven themes: symptoms and diagnosis, host resistance, factors affecting disease severity, fungicides, dissemination of the pathogen, disease development in a humid chamber, and integrated management (Table 1). The most complete work was that of Peru (Nelson et al., 2002), which had 12 practices related to PLB.

Competencies and learning objectives

Participants in the workshop identified five competencies that farmers need to effectively manage PLB. These were: i) capable of recognizing the symptoms of disease and know which organism causes it; ii) know how this organism lives; iii) identify the characteristics and benefits of using resistant potato cultivars; iv) use fungicides appropriately; and v) by periodically visiting the potato field, be able to select practices that control late blight efficiently. Fifteen capacity building components were identified and then 15 learning objectives were developed (Table 2). Learning objectives for the use of appropriate protection while mixing and applying pesticides and for pesticide application technology were not developed, as these subjects are generic and it was felt that they would be better developed in a separate facilitator's guide.

Based on the learning objectives, scientific resources, learning strategies and specific functions for the facilitator were developed. Different techniques were used to facilitate learning, for example, observation, analogies, skits, discussions, experimentation and simulation. The five competencies with learning objectives were formulated into five modules. Annexes were also developed to provide supporting

material on: i) how to construct a "knowledge test" using simple resources; and ii) basic fungicide information formulated in a fungicide guide.

Once all the material was developed, much emphasis was put on formatting. A specific format was used for each module that gave consistency and facilitated use of the guide. Page size, paper quality, font, figure content and quality, design, and language were chosen in function of field utility, user, beneficiary and gender considerations. The format of each module included: i) instructions for the facilitator before the session (prerequisites, time needed, introduction, objectives, structure of the module, and preparation for the facilitator); and ii) activities to be developed with the participants during the session (revision of the preceding module, evaluation of the existing knowledge, expectations of the participants), which included at least one practical session (objective, materials, procedure, technical notes for the facilitator, and handouts to give to participants) and final activities (synthesis of the module, final knowledge evaluation, feedback, and questionnaire). The guide was initially published in Spanish (Cáceres et al., 2007a) and then translated into Ecuadorian Quechua (Cáceres et al., 2007b) and English (Cáceres et al., 2008).

DISCUSSION

What was gained?

One valid question as a consequence of this multi-year process is: "what was gained"? As noted earlier, a number of materials for intensive farmer capacity building already existed. Why was there a need for yet another? This endeavor grew out of a realization by facilitators, communicated to the authors (S. Sherwood, pers. commun.)

that the existing materials were not covering all the necessary areas, nor were they achieving the necessary learning objectives. This can be seen in Table 1, where several existing guides do not cover key themes for PLB control. PLB is the most serious biotic constraint to potato production and arguably the most serious yield threat in many regions. If not properly managed, PLB can easily destroy a crop and leaving little or no yield.

This endeavor differed from earlier ones in the approach taken. While a number of earlier PLB publications were used as resources and for inspiration, the final content of this guide was decided by a structured and highly participatory exercise. Perhaps one of the unique qualities of the exercise was not so much its participatory nature, but rather the structured competence-based approach. One can only hope that this gives a solid underpinning to both the scope and balance of the modules. In the 2006 workshop in Quito, five competencies were identified. In a more recent workshop in Beijing, 2008, with different participants coming from a different context, a very similar set of competencies was also identified (unpublished data).

The endeavor described herein also differed from earlier ones in the way the competencies were translated into learning objectives. Here, expert guidance based in knowledge management theory assisted the process to ensure that the objectives, once met, would result in the identified competencies.

When the facilitator's guide is compared content wise with earlier versions one can see that it is similar to them, particularly the one from Peru (Nelson et al., 2002). To the extent that this guide, with its systematic methodology, resembles the earlier ones, it also validates them; to a large extent the experts who created them were on the mark.

This strengthens the idea that the present guide does not represent a revolutionary change, but rather an evolutionary step in PLB capacity building.

What was learned?

The process of developing this guide was in itself edifying. INIAP, Ecuador's national agricultural research system, adopted the process to develop guides for other aspects of potato production, and was able to convince the national government to fund the process. CIP is also currently discussing how to use this approach to improve and standardize existing capacity building materials.

Overall, the process of identifying competencies, capacity building components (mental, physical and attitudinal), information and then learning objectives was very intuitive to those who participated in the workshop. Most participants left the workshop confident that the work they had done was founded in a solid strategy and that the outputs would be effective if implemented with farmers.

This guide can be used in different participatory learning approaches, particularly in FFSs and short courses. It utilizes several different techniques to facilitate learning. It also emphasizes the importance of building on the existing farmer knowledge and subsequently developing with farmers improved knowledge by strengthening the competencies they need to control PLB. For this reason, the facilitator should act as an intermediary of knowledge and not as a traditional professor.

This guide is not intended to be highly technical in the different aspects of control of late blight. Other sources such as books, scientific articles and technical sheets (e.g., Pérez and Forbes, 2007) can be used if greater knowledge is needed. The objective of this

guide is to present the information that is essential for the participants to be able to adequately manage PLB.

Considering the educational level of the projected users and beneficiaries of this guide, it was essential to use simple language. For example, while the pathogen that causes late blight, *P. infestans*, actually belongs to the group of microorganisms known as oomycetes, in the guide it is referred to as a fungus, which is much more familiar to most people. Other simplifications have also been made in language.

The users of this guide should be able to read and write. Also it is highly recommended that they have some experience in potato cultivation and in processes of participatory capacity building. The beneficiaries do not necessarily have to know how to read and write. Therefore, it's highly recommended that users of this guide participate in a course on how it should be correctly used. This course might last two or three days and could be given by people with experience in PLB control, the use of this guide, and in the pedagogical principles that make FFSs successful. To date, three workshops were held in Ecuador to train extension workers to use the guide.

Finally, the guide should be tried and adapted to the local social and agro-ecological conditions. Furthermore, some contents are specific to each location, as for example lists of cultivars or lists of fungicides. Adaptation of the guide for dissemination in South America, Asia and Africa is foreseen.

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Tables

Table 1. Summary of activities for potato late blight management compiled from earlier sources and used for content in the elaboration of the facilitator's guide.

Theme	Nelson et al., 2002	Pumisacho and Sherwood, 2000, 2005	Gandarillas et al., 2001	Anonymous, 2000
Symptoms and diagnosis	3	1	1	
Resistance	2	1		
Factors affecting disease severity	1	1	1	
Fungicides	2	1		
Dissemination	2	1	1	
Disease development in a humid chamber	1	2		2
Integrated management	1		1	
Total	**12**	**7**	**4**	**2**

Table 2. Competencies for effectively managing potato late blight, capacity building components and learning objectives of the facilitator's guide**.**

Mental ability (MA), physical skill (PS) or attitude (A)	Information	Learning objective
Competence 1: Identify the disease symptoms		
MA: identify the symptoms of PLB and distinguish them from those of other diseases	Concept of symptom	Explain the concept of symptom and give an example related to animal diseases
	Symptoms of *P. infestans*	Describe late blight symptoms on leaves, stems and potato tubers under field conditions and how to distinguish them from those of other diseases
MA: identify *P. infestans* as the causal agent of PLB	*P. infestans* as a potato pathogen	Draw the agent causing late blight and describe how to recognize it on plants
	Structures of *P. infestans* (mycelia and spores)	Explain what *P. infestans* spores are and how they function
	Role of spores	
Competence 2. Know how *P. infestans* lives		
MA: understand the life cycle of *P. infestans* including its sources MA: relate environmental conditions to *P. infestans* growth	Life cycle and sources of *P. infestans* Role of environmental conditions on *P. infestans* growth	Explain the *P. infestans* life cycle by using a drawing, including sources of *P. infestans* and the environmental conditions that favor the various phases of the pathogen's growth

Table 2. Continuation**.**

Mental ability (MA), physical skill (PS) or attitude (A)	Information	Learning objective
Competence 3. Identify the characteristics and benefits of using resistant potato cultivars		
MA: Discriminate among immune, resistant and susceptible potato varieties.	Concepts and main characteristics of immune, resistant and susceptible potato varieties	Explain through a diagram the concepts of resistant and susceptible varieties, depicting the three main characteristics that differentiate them and the benefits of using resistant varieties to control late blight
MA: Identify the benefits of using resistant varieties	Advantages of using resistant varieties for controlling PLB	
A: Prefer resistant varieties	Resistance levels of local varieties	Explain the concept of immune cultivars and the reason why immunity is lost (optional)
	Break-down of immunity (optional)	Identify the main characteristics of local potato varieties in relation to late blight using a table
Competence 4. Use fungicides appropriately		
MA. identify the type of pesticide needed to control PLB	Concepts of pesticide and fungicide	Explain what a fungicide is and provide an example
MA: understand the following concepts: active ingredient, commercial name, working principle (contact or systemic), and formulation	Concepts of active ingredient, commercial name, working principle, and formulation	Identify the active ingredient, commercial name, working principle, and formulation of at least two fungicides
		Identify in the Guide of Fungicides provided the active ingredients, commercial names, working principle and doses of fungicides used to control late blight

Table 2. Continuation**.**

Mental ability (MA), physical skill (PS) or attitude (A)	Information	Learning objective
MA: understand the main criteria used in deciding which fungicide to apply and the frequency of its application	Concepts of prevention and fungicide effectiveness Effect of the following factors on fungicide use: amount of late blight in and around the crop, environmental conditions, potato cultivar, crop growth stage and period since the last application	Explain the criteria used in deciding which fungicide to apply and the frequency of its application Decide which fungicide to apply and the application frequency in a specific situation, considering the criteria explained before
A: use appropriate protection while mixing and applying	Knowledge of risks involved	Not considered
MA: understand concepts of pesticide application technology PS: apply pesticides correctly	Backpack calibration, selection of nozzles, etc.	Not considered
Competence 5. By periodically visiting the potato field, be able to select practices that control late blight efficiently		
A: visit the potato field frequently	Late blight evaluation under field conditions	Explain the importance of frequently visiting the potato plot for late blight evaluation
MA: decide a control measure for PLB	Practices for PLB control other than fungicide use (high hilling, defoliation, etc.)	Identify practices for controlling late blight based on field observations

Figures

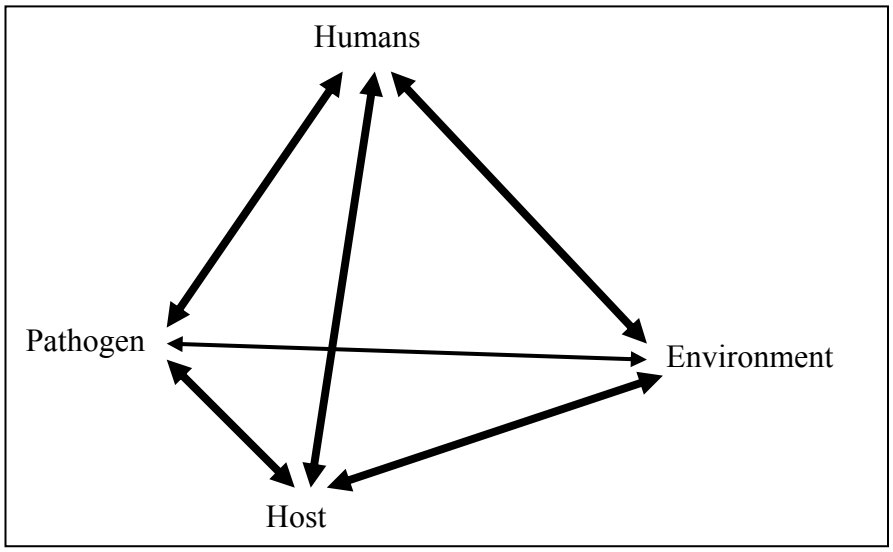

Fig. 1. The disease tetrahedron (after Zadoks and Schein, 1979).