Impact on a Changing World

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Understanding Farmers' Responses to Late Blight: Evidence from Peru, Bolivia, Ecuador, and Uganda

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It is ultimately a farmer's decision whether or not to adopt a technological solution to a problem. In developing countries, however, information for farmers' decision-making is scarce, and the infrastructure for generating and maintaining decision-support systems to assist farmers is deficient. Therefore, in order to identify potential points for intervention in disease management, it is necessary to understand how farmers respond to diseases such as late blight in potatoes. As a first step toward this understanding, a baseline study was conducted in Peru, Bolivia, Ecuador, and Uganda between November 1997 and August 1998. The results of this study will help the participatory development of integrated late blight (LB) management. Specific objectives of the study were (1) to estimate losses in yield and income due to this disease; (2) to document farmers' knowledge and practices (particularly of fungicide use) in relation to LB control; and (3) to document potato-related activities of extension organizations at the pilot sites.

Methods

For each of the four countries, a semi-structured questionnaire was the main data collection tool. Additionally, informal interviews, focus groups, non-participant observation, and field evaluations were used to enhance the validity of the research. The research was carried out in collaboration with personnel from the corresponding national programs.

Pilot sites were selected where potato is an important crop, and where LB is endemic. In Peru, the work was focused in the Department of Cajamarca with the participation of 131 farmers. In Bolivia, data were collected from 45 farmers in Ayopaya Province. Two hundred and seven farmers in the Ecuadorian provinces of El Carchi, Cotopaxi, Chimborazo, and Bolivar were included, and in Uganda, Kabale, Kisoro, and Mbarara districts were included in the research with data collected from 118 respondents. This paper summarizes the main findings of this study in the four countries. Information is based on the data collected by teams working in each of the countries and the reports written by those teams.

Results and Discussion

Farmers and the potato systems

The potato crop was important for income and food security at each pilot site, although it was one of several crops managed by farmers. Most informants in the study were small farmers with less than 5 ha of land. The majority owned their land. In Uganda and Ecuador, a sizable minority (28% and 14%, respectively) were tenants.

Most of the participating households derived the bulk of their income from agriculture and livestock management. Some farmers (less than 30% of informants in Peru and Uganda) also depended on off-farm activities to generate supplementary income, such as small businesses, temporary labor, and artisanal activities.

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On average, Bolivian and Peruvian farmers planted less than 1 ha of potato, which is typical for subsistence farmers in the Andean Region. In the Ecuadorian case, the figure was higher (1.8 ha) because the sample included commercial areas such as El Carchi Province. In Uganda, however, farmers grow about a fifth of a hectare (0.18 ha) in potato because they have less land available for cultivation. Yields varied across countries. In Bolivia 12.7 t/ha, and in Ecuador 12.6 t/ha were reported. These numbers represent relatively good yields compared with Peruvian farmers who harvested an average of 4.9 t/ha. In Peru, yield was greatly influenced by the adverse weather conditions caused by "El Niño" during early 1998. In Bolivia, Ecuador, and Peru, yields were evaluated by sampling fields; in Uganda, yields were estimated from information provided by farmers where an average of 7.0 t/ha was reported.

Importance of late blight for farmers

From the farmers' point of view, LB is considered either as the primary or secondary potato pest in the pilot sites in the four countries. Figure 1 presents the indexes obtained from the farmers' ranking of pest problems in Peru and Uganda. The Peruvian case also applies to Ecuador and Bolivia. In all countries, however, LB was not the only problem. There were other pests that caused concern and were perceived as reducing potato yields and quality. In Uganda, for example, bacterial wilt was ranked as more important than LB. In Ecuador, Bolivia, and Peru, the Andean potato weevil ranked just below LB as a key pest (Ortiz et al., 1996). Hence, in designing programs for the improved management of potato pests, it is important to recognize that farmers face multiple problems.

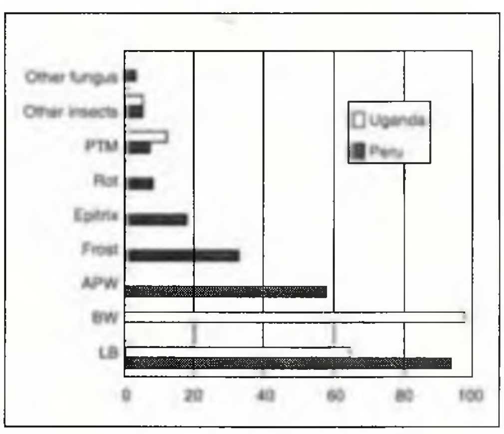

Figure 1. Index of pest problems perceived by farmers in Peru (n=131) and Uganda (n=118). Note that farmers in Peru consider frost a pest. Key: LB: Late blight, BW: Bacterial wilt, APW: Andean potato weevil, PTM: Potato tuber moth.

Late blight damage was evident during field evaluations in the Andean countries, but damage varied according to a number of factors (Table 1). The disease increased during the potato season, and those fields that were planted late (coinciding with the rainy period) tended to have more damage. Late blight damage was inversely correlated to fungicide applications. Plot location and the cultivar of potato that farmers used also influenced disease damage.

Potato fields were evaluated during the growing season and also at harvest time in Peru, Ecuador, and Bolivia. In Uganda, this part of the study will be repeated in 1999. Considering potato yield as a dependent variable, and disease damage as an independent variable and controlling for other factors, it was clear in Peru, Bolivia, and Ecuador that LB reduces potato yields. Figure 2 illustrates the negative relationship between LB damage and yield in four Bolivian communities, where an R^2 of 0.8 was obtained. In addition, data from Peru and Ecuador also provided evidence of the devastating effects of this disease at the field level.

A conservative 20% difference in severity between appropriate and inappropriate LB control can be used as the lower bound to estimate losses. According to estimates, each 20% increase in LB severity reduces yield from between 1 t/ha (in Peru) to 4 t/ha (in Ecuador). This conservative

Table 1. Regression of late blight severity in the Peruvian sample.

Variable	t-statistic[a]	Coefficient
Days after planting	0.31	2.06 **
Days after planting squared	0.002	3.10 ***
Planting date	0.55	10.18 ***
Fungicide applications	- 1.21	- 2.88 ***
Potato varieties:		
Amarilis	- 14.40	- 3.74 ***
Canchan	15.20	4.10 ***
Chaucha	- 9.45	- 1.84 *
Liberteña	- 8.86	- 2.70 ***
Perricholi	1.01	0.18
Yungay	4.35	1.18
Places		
Contumaza	10.08	2.45 **
San Miguel	8.58	2.59 ***
Constant	- 7568.41	- 10.18
Number of observations		355
R^2	0.54	

[a] t-statistic reference location is Cajamarca and varieties are those that are either native or not used by a substantial number of farmers. *, **, and *** indicate significance with 99%, 95%, and 90% confidence, respectively.

estimate is lower than the figures reported by Baylon (1987) who indicated losses of about 6 t/ha in Peru, and those reported by Thiele et al. (1998) who indicate that an average of 6.5 t/ha could be lost to LB in Bolivia.

With 1998 prices, US$140/t, a reduction in potato yield would mean a loss of between US$140/ha to US$560/ha in Peru, and between US$250/ha and US$1,000/ha in Bolivia where potatoes are valued at US$250/t. For small farmers, yield reduction caused by LB causes a significant loss of income from their land, and reduces food availability for the household.

It is difficult to extrapolate the results of a pilot study to the situation in an entire country, but the extent of the losses can be estimated. In Peru, farmers grow an average of 250,000 ha of potatoes per year. Using conservative estimates, 20% of the total area planted to potatoes could be severely affected by LB each year. This would mean a total monetary loss of between US$7 million and US$25 million per year. In Bolivia, Thiele et al. (1998) report that LB affects 20,000 ha. Using 1998 potato prices, this represents a loss of between US$5 million and US$20 million per year. It is clear that this range of losses justifies investment in developing control strategies. And any strategy that can contribute to the reduction of LB damage will have a direct effect on increasing yields, and in turn, farmers' income and food security (Torrez et al., 1999).

Farmers' knowledge of late blight and practices to control the disease

Unlike insects, diseases are difficult to see; farmers do not usually know the causal agent of plant diseases (Bentley, 1990, 1991). This was confirmed by the findings of this study that showed that farmers lack

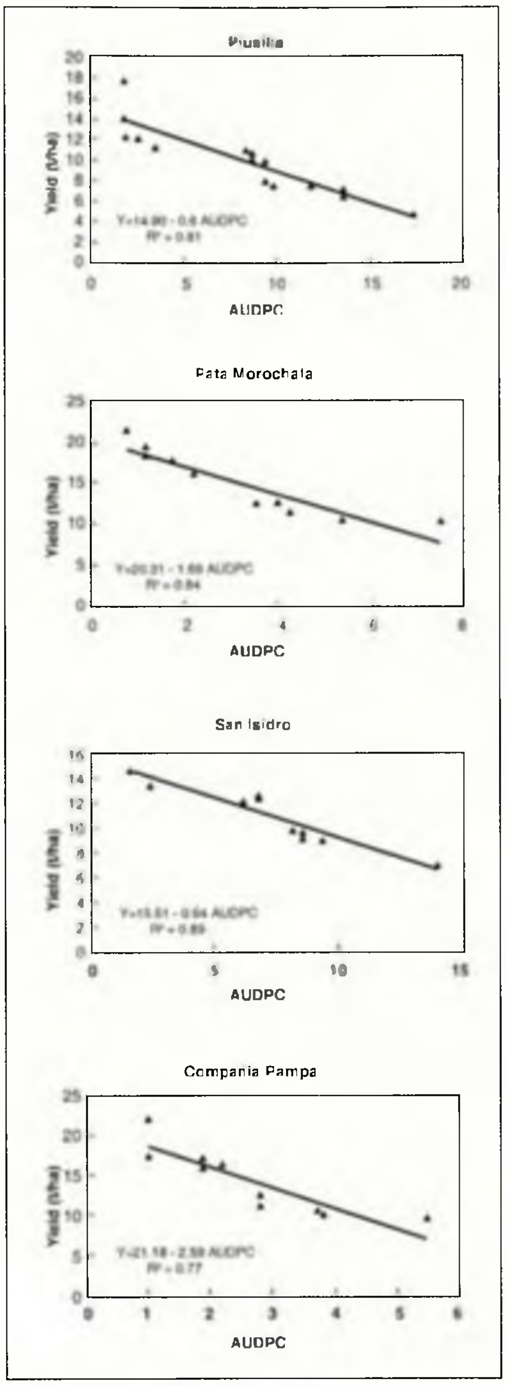

Figure 2. Relationship between late blight damage and yields in four Bolivian communities during 1997-1998 cropping season. Key: AUDPCr (area under the curve - an index for disease progression).

knowledge of late blight biology. Most of them did not know that the real cause of late blight is a microorganism. They associated the disease with the weather conditions that favor its occurrence such as heavy rainfall, fog, cold weather, and even lightning. Additionally, farmers were unable to correctly diagnose the disease. More than 88% of informants confused the symptoms of late blight with other fungal diseases or with "leaf burning" caused by excess pesticide use.

When asked about different control practices, farmers in all the participating countries were most familiar with fungicide use, and LB control is largely based on this chemical control method. In Uganda about 69% of farmers used fungicidal products compared to more than 95% in the Andean Countries. Yet it was clear that most farmers did not know how to differentiate contact fungicides from systemic fungicides, and they tended to spray any available product according to their experience.

During the study period, farmers sprayed an average of 3 times per cropping season in Uganda and Bolivia, 5 times in Ecuador and 7 times in Peru (3 to 4 sprays are common in Peru in a normal year). The number of sprays was influenced by local weather conditions. According to a multi-variable regression analysis run in Peru, fungicide use was influenced by a number of factors (Table 2). Younger, educated, and wealthier farmers tended to spray more. The planting season also influenced fungicide use; those farmers who planted in the rainy season sprayed more often because this period is most conducive to the disease. Plot location also influenced the pattern of fungicide use, so farmers spray more frequently in those places that have higher relative humidity (San Miguel and Contumaza shown in Table 2). It is important to note that there is no evidence that the use of resistant cultivars influences fungicide use in Peru. The reason may be that most farmers plant resistant and susceptible cultivars together (in strips) and

Table 2. Regression on fungicide use in the Peruvian sample.

Variable	Coefficient	t-statistic[a]
Age	-0.04	- 1.95*
Education level	0.26	2.33**
Family labor	0.01	0.06
Land owned	0.53	2.16**
Potato varieties:		
Amarilis	-3.66	-0.66
Canchan	0.47	0.84
Chaucha	1.38	1.63
Liberteña	-0.35	-0.62
Perricholi	0.93	1.22
Yungay	-0.18	-0.37
Planting date	0.21	3.27***
Places		
Contumaza	3.34	4.24***
San Miguel	3.38	4.29***
Constant	- 286.03	- 3.22***
Number of observations		131
R^2		0.56

[a] t-statistic reference location is Cajamarca and varieties are those that are either native or not used by a substantial number of farmers; *,**, *** indicate significance with 99%, 95%, and 90% confidence, respectively.

tend to spray both at the same time. Evidence from the countries included in this study shows that each farmer may have his own control strategy, as opposed to the uniform control strategies used in temperate countries (Mackenzie, 1981).

The Peruvian and Bolivian data indicated that the number of sprays was inversely and significantly associated with the extent of LB damage. Potato fields in which farmers sprayed more tended to have less damage.

Farmers used a number of commercial products with a range of active ingredients (Table 3). In Uganda just two active ingredients were found on the market. Between six and eighteen were present in the Andean countries. Mancozeb was by far the most commonly used active ingredient in Uganda because it was relatively inexpensive. At the Bolivian pilot site, farmers used up to six active ingredients; propanocarb was the most common. The Peruvian pilot area presented more variability of active ingredients. A total of 13 different ingredients was found in the sample, and metalaxyl was the most commonly used. The Ecuadorian case had an even higher variability of chemical products to control LB (up to 18), and the most common active ingredient, mancozeb, was used in a total of 47% of applications. This variability of chemical products used to control LB, mixed frequently with insecticides, represents a threat to other living organisms (Pilling and Jepson, 1993; Schuster and Schoreder, 1990). The higher variability of active ingredients in Latin America also reflects the growing market for pesticides in the region, in comparison to the less developed market for these products in Africa (Repetto and Baliga, 1996).

Table 3. Main active ingredients used as fungicides by farmers in the pilot sites.

Country	Active ingredients	Most common active ingredients[a]	Proportion of sprays (%)
Uganda	2	mancozeb	90
		metalaxyl	9
Bolivia	6	propanocarb	44
		ofurace + mancozeb[b]	25
		chlorothalonil	19
Ecuador	18	mancozeb	25
		cymoxanil + mancozeb	16
		cymoxnil + propineb	9
		sulfur	6
Peru	13	metalaxyl + mancozeb	42
		mancozeb	24
		propanocarb	19
		metiram	7

[a] Only the most common active ingredients are included in this column.
[b] (+) Means both active ingredients were combined in the same commercial product.

There was also a great deal of variability of fungicide doses used by farmers to control LB. In Peru, for example, farmers tended to use less than the recommended dose. In commercial potato growing areas in Ecuador, however, farmers tended to use a higher dose than that recommended, generally by mixing different chemical products (Crissman et al. 1998). In Uganda, 30% of farmers also used more than the recommended dose. But, according to farmers and extension officers, the reason is the existence of adulterated products. Farmers increased the dose in order to make sure that they could control the disease.

The cost of fungicides was difficult to elicit from farmers because in most cases they did not keep records of the products they use. However, costs in Peru and Ecuador average US$140/ha and US$150/ha, ranging from zero to US$500/ha. These estimates are equivalent to 10-15% of total production costs. This is consistent with data reported by Baylon and Otazu (1987) in Peru, and Crissman et al. (1998) in Ecuador. An important issue is that pesticide use represents an out-of-pocket cost. The challenge is to develop less expensive methods of pest control using either nonchemical or more appropriate chemical methods, so that farmers can reduce the amount of fungicide they use.

Cultivar use and LB damage

Between 50% and 100% of farmers in the four countries were aware of the differences in LB resistance of potato cultivars. However, farmers preferred particular cultivars for more reasons than just LB resistance. Farmers in Uganda preferred cultivars that matured early. They wanted to harvest potatoes in approximately four months in order to have the land free for another crop. In Peru, earliness was less important because most farmers have only one growing season per year. Among the Peruvian farmers, 85% preferred cultivars with resistance to LB, whereas in Uganda only 12% of farmers felt that resistance was an important attribute. LB was not their main source of concern.

Evidence from Peru suggests that LB severity is statistically correlated with cultivar use (see Table 1). There were cultivars (Amarilis, Chaucha, and Liberteña) that showed resistance at the field level. There were also susceptible cultivars such as Canchán. This suggests that genetic resistance can play a key role in reducing LB damage at the field level, and that resistant cultivars can be a crucial component of an integrated management strategy against this disease. The continuous deployment of resistant cultivars would mitigate the risk associated with resistant cultivars currently in the field becoming susceptible to LB.

Extension activities and LB control

In Peru, Bolivia, and Ecuador, nearly all institutions working with agriculture in the pilot areas focused to some degree on potato production. In Uganda, however, this was not the case because potatoes are not as important a crop there as they are in the Andes. Government extension services in all four countries were inappropriate in terms of number of extension personnel, coverage and facilities. However, non-government organizations (NGOs) have been increasingly participating in providing these kinds of services to farmers (Bebbington and Thiele, 1993).

The main potato-related activity carried out by extension organizations is the provision of technical assistance, particularly related to the use of agro-chemicals, and the provision of credit though revolving funds for seed, fertilizer, and pesticide. The participation of NGOs as pesticide providers to farmers has increased in recent years. However, evidence suggests that extension institutions are also important sources of new potato seed for farmers, so that new cultivars could be distributed through this channel.

Farmer training on LB biology and how to control this disease is limited. Most organizations still use a top-down technology transfer approach based on providing recommendations. This could have negative implications when trying to promote integrated pest management. This technology requires horizontal and participatory methods of exchanging information and knowledge as suggested by Röling and Van de Fliert (1994), and Torrez et al. (1999).

Conclusion

According to farmers' perceptions, LB ranks as the most important pest problem in the Andean countries included in the study, and as the second most important pest in Uganda. Farmers' concern with LB is understandable considering that, as this study shows, this disease indeed reduces potato yields, and is a real threat to potato production, food security, and farmers' profits. This suggests that investment in developing and disseminating control strategies in developing countries would be profitable. However, LB is also part of a complex pest system that depends on location, type of farmer, and management strategies. Development of control strategies must be flexible enough to integrate other local pests of economic importance. In addition, pest control is only one of several endeavors for farmers, therefore any control strategy should be adaptable to existing production activities and goals.

Farmers' lack of knowledge about biophysical principles related to pest control was a common feature in the participating countries. Any effort to improve pest control at the field level should start by providing farmers with missing information, so that they can acquire new knowledge. However, to what extent new knowledge about biophysical principles would be reflected in better decision-making about the control of LB is a question that remains unanswered.

In spite of the negative effects of fungicide use on peoples' health and the environment, these products are still the primary control measure at the field level. Fungicide use does reduce LB damage and increases potato yields. Evidence suggests that there is room for including fungicide use in LB control strategies, at least until other control options are available. Farmers in the developing countries studied, however, lack knowledge about the appropriate use of fungicides.

The study demonstrated a clear relationship between potato cultivars and LB damage at the field level. Hence, genetic resistance can play an important role as part of an integrated management strategy against this disease, and may be a way to reduce fungicide use per hectare. However, so far there is no evidence that fungicide use has been reduced.

Inter-institutional cooperation becomes a key issue in overcoming difficulties encountered by extension services and to facilitate farmers' access to new information, knowledge, and resistant cultivars. Participation of all persons involved, particularly farmers, is required to develop and disseminate control alternatives in order to reduce the devastating effects of LB in developing countries.

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