How farmers benefit from plant clinics: an impact study in Bolivia

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Between 2000 and 2009, nine plant clinics in three agro-ecological areas of Bolivia (Andes, lowlands and valleys) served about 800 communities in an area roughly 300 × 100km. Over 6000 farmers consulted these clinics with 9000 queries. Many found the advice so useful that they visited the clinics repeatedly. A survey of 238 clinic users found that most adopted the clinics' recommendations. Fruit and vegetable growers who followed the clinic recommendations tended to spend less on pesticides. As for certain crops like potato, citrus and peach palm, a modest increase in pesticides helped improve the quality and quantity of the harvest. Farmers improved their incomes by following the clinics' advice. The poorest farmers enjoyed the greatest increase in income per hectare. This was the first study to explore the impact of plant clinics; future studies need to be improved, for example by obtaining baseline data and by comparing clinic users to their peers who have not used clinics.

Keywords: agricultural extension; Bolivia; farmer benefits; impact assessment; plant clinics; plant health; smallholder farmers

Introduction

Plant clinics (*Postas para Plantas*) began in the town of Comarapa, Bolivia, in the year 2000, when a laboratory called LADIPLANTAS was opened by CIAT (Centre for Tropical Agricultural Research, of the departmental government of Santa Cruz, not to be confused with CIAT in Cali, Colombia – the International Centre for Tropical Agriculture). By 2003, CIAT and PROINPA (the Foundation for the Promotion and Research of Andean Products) had started plant clinics in weekly farmers' fairs (Boa, 2009). By 2009, nine plant clinics were operating and had logged over 9000 queries from 6000 people, for over 100 crops in 800 communities (Bentley *et al*., 2009).

The plant clinics were created as a service to share information with farmers. The clinics had little money and no intended end date. They were run by three Bolivian institutions: CIAT (local government research), UMSS (Public University of San Simón) and PROINPA (privatized agricultural research agency with a public mandate). Some local municipalities contributed funds or a place to operate. The clinics received a small grant from the Global Plant Clinic (GPC) in the UK to cover some operating costs. The clinics were run by active citizens working with competent public agencies (Green, 2008).

LADIPLANTAS is open every day, but the other clinics function just once a week, usually on a market day, when farmers come to the small towns to buy and sell. These markets or fairs are eminently public places, crowded with smallholder farmers. The plant clinic sits in the middle of this fair. Physically, it is merely a few chairs and a table, some posters and a welcoming sign (Figure 1). The agronomist who runs the clinic waits for farmers to drop by, it

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Figure 1 | Farmers crowd around the plant clinic in Tiraque (left). Fredy Almendras (in white cap) gives Eusebio Terrazas some advice regarding his papaya problems

is hoped, with a sample of an ailing plant. The agronomist listens to the farmers' plant problems, offers advice and summarizes it in a written recommendation, like a prescription. The agronomist offers advice based on his or her experience, and this advice improves over time, as they become more familiar with local problems and send samples to the lab for results (see Bentley *et al*. (2009) and Danielsen and Kelly (2010) for more details on clinic operations). In theory all farmers have access to fairs (and to the clinics based there). Many women attend the fairs and services are available in Quechua (favouring women, the elderly and the poor), although people from the farthest villages and the elderly may come less often.

In 2009, nearly 10 years after the authors and colleagues started plant clinics in Bolivia, we realized that an evaluation of benefits obtained by farmers was overdue. The clinics had grown in fits and starts. They had evolved without solid funding and with no secretariat or director to manage them. The clinics were open to all members of the public, hence there were no designated 'participant villages' that one could contrast with 'control villages' so as to determine the benefits of attending a clinic. Yet there had been a guiding intention: to improve farmers' livelihoods through scientific diagnosis and advice on pest and disease management, for any problem, on any plant. The ad hoc method we used to start clinics included only crude monitoring and evaluation (e.g. the clinic staff kept a log of users and problems). We made no plans for impact assessment and made no arrangements for a quasi-experimental design (e.g. no control groups). For the first several years we were simply trying to give farmers a disinterested source of advice, an alternative to agricultural supply shops. Merely figuring out how one could keep the plant clinics running involved a lot of learning. Bolivia has no national extension service and through much of the study period did not have a national agricultural research service either. Santa Cruz had extension services (SEDAG) hosted by the departmental government, but the department of Cochabamba did not.

The experimental method demands a control group, which is unfeasible in social research; no two groups of people are exactly alike. But it is possible to find groups that are similar. For example, researchers in Benin compared groups of women who had seen videos or attended training with those that had done neither. The women who watched the videos experimented more with the techniques they had seen (Zossou *et al*., 2009). These groups formed a kind of fortuitous experiment, complete with control groups, amenable to study.

How to evaluate an IPM (integrated pest management) programme

Because IPM programmes promote specific crop management practices, it is straightforward to identify cause and effect (e.g. farmers learn information, adopt new behaviour and manage pests to increase yields and reduce pesticide use). While there are no agreed-upon standards to quantify IPM impacts, the indicators measured are usually: (1) the reaction of beneficiaries, (2) knowledge gain, (3) adoption of IPM practices, (4) reduction in pesticide use and (5) the increase in yield or profit.

Although few IPM programmes have been properly evaluated, there are several quasi-experimental methods available (see Peshin *et al*., 2009). An impact assessment allows researchers to state with statistical certainty that a project had a certain result. An impact assessment demands a control group and baseline data taken that concern both the control group and the treatment group. Davis *et al*. (2009) used before and after data for farmer field school (FFS) graduates and control farmers in East Africa. They found that FFS led to higher productivity and income, although the poorest farmers did not benefit significantly.

We lacked a control group, and we opted for the 'one-group before and after' method, measuring changes in clients before and after visiting the clinic (Peshin *et al*., 2009). Since we lacked baseline data, we asked farmers how much they spent and harvested before and after having visited the clinic. Admittedly, this study has several weaknesses, including its reliance on recall data, the lack of a control group, a non-randomized sample and the use of different years for different households. Some colleagues argued that this was not an impact evaluation, even though interesting findings emerged. Regardless of the study's limitations, it is important to judge the plant clinics as objectively as possible. Proponents of a new idea for sustainable development have an obligation to themselves and others to judge their work quantitatively with the data that they do have and to not simply base their arguments on qualitative evidence.

Methods

A single study should focus on just a few impact indicators that show the effect of the programme (Ravallion, 2001). We asked farmers two main questions on the crop they consulted at the plant clinic: how much money they spent on crop protection and how much they harvested before and after applying the recommendation. We assumed that the changes in plant protection costs and in harvest values were due to improved pest management. Bolivian team members hired to perform the evaluation were in close and regular contact with local people and agriculture and were convinced that farmers were not making other changes (e.g. fertilizers or irrigation) that boosted yields, nor were there significant changes in growing conditions or in pest and disease pressures through the study period.

We calculated net financial benefits achieved by these farmers on the basis of changes in plant protection costs and of changes in the quantities of harvest. Norton and Swinton (2008) and colleagues (Mauceri *et al*., 2007; Moyo *et al*., 2007; Ricker-Gilbert *et al*., 2008) discuss the assessment of the impact of IPM programmes, by measuring the adoption of recommendations. They do not calculate the benefits of the programme with regard to each farmer, but extrapolate cost and yield data from experimental stations, from a collaborating farmer's field or from interviews with scientists and extension agents.

Plant clinic staff was trained and obtained support from their institution. They were professional agronomists and were motivated to find answers to farmers' problems. The clinic staff comprised honest information brokers without ulterior motives such as that of selling pesticides or pushing a specific technology. We asked farmers how much they had planted and harvested, yields estimated conservatively. If a farmer said he had planted eight bags of potatoes, and we thought he had planted 20, we took him at his word and recorded 'eight bags'. We used the lower range of prices. We trusted farmers' recollections of past production and yield figures. Farmers remember these things because they are key facts for their survival. Although the recollected data are relatively accurate, the recollection of events that occurred more than one year ago may be weaker; the method needs to be improved in future studies.

Sampling

Bolivia has plant clinics in three geographically different areas: the Andes of Cochabamba, the Amazonian lowlands of the Chapare and the Valleys of Santa Cruz (Figures 2 and 3, Table 1). We used opportunistic sampling, that is we interviewed every clinic user that we could find (Figure 4). This led to an over-sampling of those who were:

- residing closer to the road or near the community centre
- known to the interviewers
- in large communities with many clients of the clinics.

From 22 June to 29 July 2009, we interviewed 238 farmers.

We wanted a similar sample size from each area, but the Chapare operated clinics for a shorter period of time and had far fewer clinic users than did the other areas, merely 196 queries out of the 9000. The people of the Chapare are settlers from the Andes who colonized the lowlands, especially after 1984 (Buzzone and Clavijo, 1990). The settlers in the Chapare lived far apart and were hard to find; we interviewed fewer people there. Our sample from the

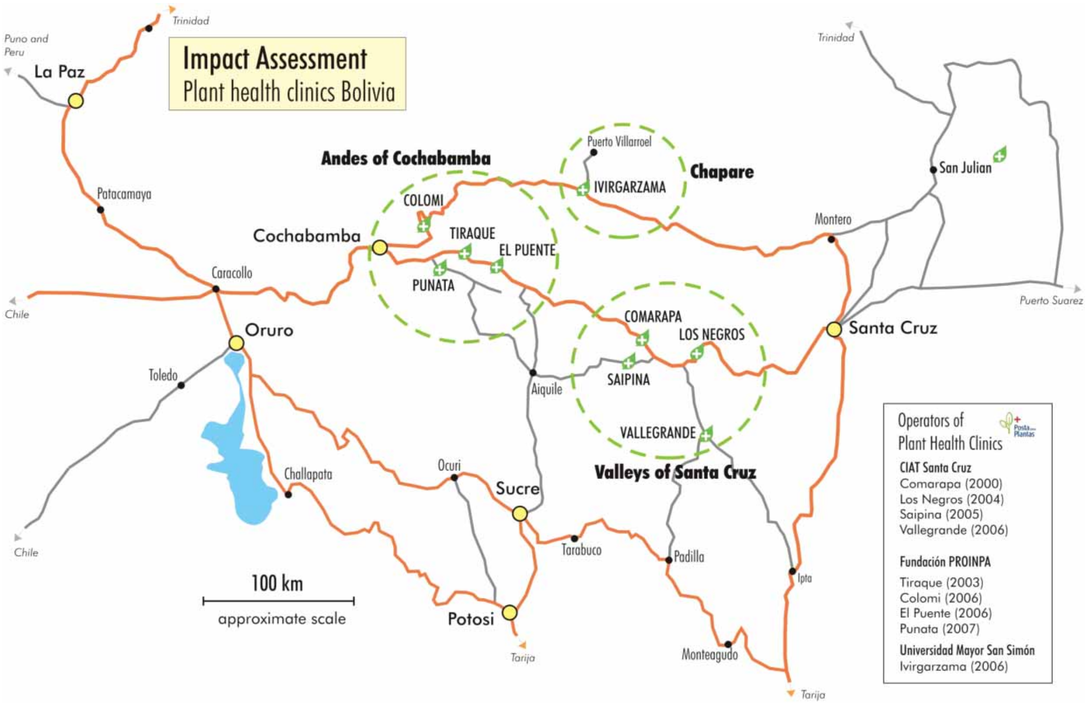

Figure 2 | Location of plant health clinics in Bolivia

Figure 3 | There were three study regions with distinct environments and crops: the humid tropics of the Chapare (top), the cool, dry Andes of Cochabamba (lower left) and the temperate valleys of Santa Cruz (lower right)

valleys of Santa Cruz included farmers from most municipalities, because CIAT had regular contact with farmers and with staff in various towns. People from 800 communities consulted the plant clinics and 96 of those communities were sampled in this study.

Table 1 | **Culture and geography of study areas, farmers surveyed and clinic use through 2009**

	Andes of Cochabamba	The Chapare	Valleys of Santa Cruz
Farmers interviewed ($n = 238$)	114	27	97
Clinic clients up to 2009 ($n = 6815$)	4177	124	2514
Clinic visits up to 2009	4747	196	4252
Main crops consulted by interviewees	Potato	Citrus, palm	Tomato, strawberry, potato, peach
Main crops grown	Potato	Bananas, coca, citrus, palm	Temperate fruits and vegetables
Clinic locations	Tiraque, Colomi, El Puente, Punata	Ivirgarzama	Comarapa, Saipina, Los Negros, Vallegrande
Geography and climate	High (3000m and higher), dry (about 500mm of rain) with little irrigation. Cool and sunny	Lowlands below 300m, wet, with rainfall nearly 6000mm in places. Humid tropics	Altitudes of 1500 to 2500m, rainfall over 500mm, but seasonal. Irrigation in some areas. Temperate
Language and culture	Primarily Quechua, native Andean peoples	Quechua and Spanish. Andean settlers in the Amazonian lowlands	Spanish-speaking family farmers with a long history of tradition in the area

Study questionnaire

Robert Chambers described the weaknesses of questionnaires in 1983; what he said is still true (Chambers, 1983). Most questionnaires are too long, with too many pointless questions. The data are so difficult to code that most survey forms never leave the cardboard box once they are put there. Although questionnaires are necessary for quantification, researchers often overestimate how many questions are needed and underestimate the size of a sample (Bentley and Baker, 2002).

Figure 4 | Local resident Clemente Baltazar (L) tells Oscar Díaz where to find those people from Boquerón Q'asa who had visited the clinic. Fredy Almendras (R) checks the names against our list

Our short questionnaire was one page long, with 18 questions (see Appendices A and B). It started with some basic information: *Farmer's name, Code* (a serial code for each interview), *Community, Municipality, Query code(s) from the clinic register* (the number assigned to each farmers' query at the clinic, that is a unique identifier for each problem consulted, not for each farmer) and *Recommendations from the clinic register*.

The interviewer copied the farmer data from the clinic records, maintained by plant clinics on Excel spreadsheets. This prompted the interviewer to review the client's case before (or at least soon after) the interview. The following questions were the first ones the interviewer asked the clinic client. The questionnaire provided space to write the answers, but verbatim responses were difficult to code and tedious to type.

The farmers understood Question 9 (*What did they recommend to you in the clinic?*) and readily answered it, explaining the recommendation they had received, as well as they remembered it. We used this to code how well the interviewees remembered the recommendation, on a scale of 0–3.

Question 10 (*What did you do?*) allowed us to code for adoption (Table 2). For example, if a farmer said, 'I dug up the spots where I stacked my potatoes

Table 2 | **Number and gender of farmers interviewed by study area**

Area	Women and men	Men	Men (%)	Women	Women (%)
Andes	114	111	97.4	3	2.6
Valleys of Santa Cruz	97	83	85.2	14	14.8
Chapare	27	23	85.6	4	14.4
Total	238	217		21	

(where the weevils pupate) and sprayed insecticide at the base of the plants as they were emerging', he was scored '1' (adoption). If he said, '*I sprayed my potatoes with two capfuls of insecticide*', he was scored '0' (non-adoption).

We included Question 11 (*Why did you do it like that?*) so farmers could explain their motives for accepting or rejecting recommendations. Farmers found the question dull and replied '*because I wanted to control the pest*'.

During the first few interviews, we realized that many people had had previous contact with extensionists, which might have influenced how they perceived our recommendations. We added Question 12 (*Receives training in addition to the clinic?* YES or NO) to compare clinic clients who had and had not received additional training.

As for their well-being status, or relative poverty, the interviewers checked off a box to rank households on a scale of 1–3 (Figure 5):

(1) *Poor*: Owns little or no land. Has a small house, usually owns no livestock.
(2) *Medium:* Farms less than 5ha. Has a larger house, livestock and may have some machinery, for example an old car.
(3) *Not poor*: Farms over 5ha. The house often has a garage and machinery, for example a truck and a tractor.

At the end of the questionnaire we asked where people had heard of the clinic.

We started with seven codes for the adoption of clinic recommendations, later reduced to two: no adoption and adoption. Future studies should include a code for partial adoption.

Figure 5 | The well-being of interviewees, classified into poor, medium or not poor. *Poor*: small house in the Andes thatched with straw. *Medium*: a bigger house, with tiled roofs. *Not poor*: house with a garage for a truck, a tractor and cattle

The questionnaire included two questions on changes in plant protection costs and harvests (the two main indicators). The original wording was:

> Did the recommendation save you expenses or increase your costs? How much?
>
> How much did you avoid losing because of the recommendation, or how much would you have lost if you had not applied the recommendation?

The interviewers got confused asking these questions, partly because the Spanish word for 'save', *ahorrar*, is usually used for bank savings. The second question was confusing because it did not specifically mention 'harvest'. During the first week of the study in Cochabamba, we realized that the questions were awkward, and Bentley tried to explain them better to the interviewers. In the second week in the valleys of Santa Cruz, the interviewers suggested the following changes:

Question 13a *Production costs before using the recommendation* **and** *Q13b Production costs with the recommendation*

Question 14a *Harvest before using the recommendation* **and** *Q14b Harvest with the recommendation*

The revised questions were clear to the interviewers, allowing sensitive translations into colloquial Quechua or vernacular Spanish, so farmers understood the questions.

Crop yield data varied in space and time because the clients used difference reference years. For example, for one farmer might reference 2005 as 'before' while another farmer referenced 2001 as before. Farmers attributed the yield gains to the recommendations, not to the weather or other new techniques. Changes in labour costs were not included in the calculations, but few of the recommendations required more labour.

Interviewers completed the one-page questionnaire during the survey and usually the same day, typed the data into an Excel spreadsheet. Entering the data while it is fresh in the interviewers' minds reduces transcription errors.

Results

Access and geographical areas

More women were interviewed in the valleys of Santa Cruz and in the Chapare than in the Andes (Table 2), but only about 9 per cent of the people interviewed were women. The implication is that the Bolivian clinics need to try harder to reach women farmers.

The poor had access to the clinics, although the numbers of poor clinic users varied by region (Table 3). Land and jobs are abundant in the Chapare so there are fewer poor farmers. There are more poor people in the valleys of Santa Cruz, where many landless people work as sharecroppers. In the high Andes, the land reform after 1953 gave land to many families (Dunkerley, 1984); there are few poor, many in the middle, and few in the top well-being category. Clinic users are probably representative of the well-being categories within their communities. While the poorest (usually elderly people) may visit the fair less often, the wealthiest have cars and trucks and are more likely to skip the fair and go to the city.

Table 3 | **Variation in well-being across the study areas**

Well-being status	Andes	Chapare	Valleys	Total
1 Poor	8	0	48	56
2 Medium	100	23	28	151
3 Not poor	6	4	20	30
Private company	0	0	1	1
Total	114	27	97	238

Use of plant clinics

People in the valleys of Santa Cruz made repeated visits to the plant clinics more often than did people elsewhere (Figure 6). This is perhaps because of the regular interaction between CIAT and farmers and because of CIAT's strong public mandate; LADIPLANTAS is open every day and CIAT often sent several staff members to a clinic instead of just one. But distances and road conditions to town are roughly similar across the different clinics. A few people attended several clinics in different places, suggesting that they learned to recognize and value the clinics and sought them out in various places.

The benefits of attending a clinic were spread over a wide area. People who visited CIAT's plant clinics in Comarapa, Vallegrande, Saipina and Los Negros came from an area about 150km wide, including most major communities in the area (Figure 7). The results from Cochabamba were similar. Bolivian clinic users came from 800 different communities.

The farmers surveyed consulted the clinic for 21 different crops (Table 4). We interviewed them for only one crop, even if they had brought several to the clinic.

The three study areas have different climates and altitudes, with few crops in common. Queries from the Andes of Cochabamba were for potatoes (99 per cent of the interviews). The Chapare queries were

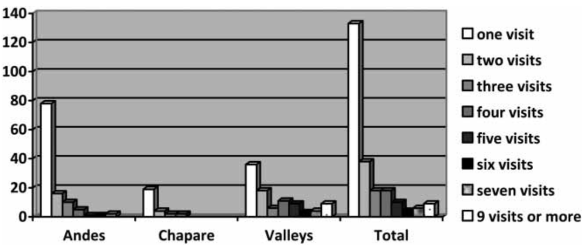

Figure 6 | The number of single and repeated visits to the clinics by clients in the three study areas

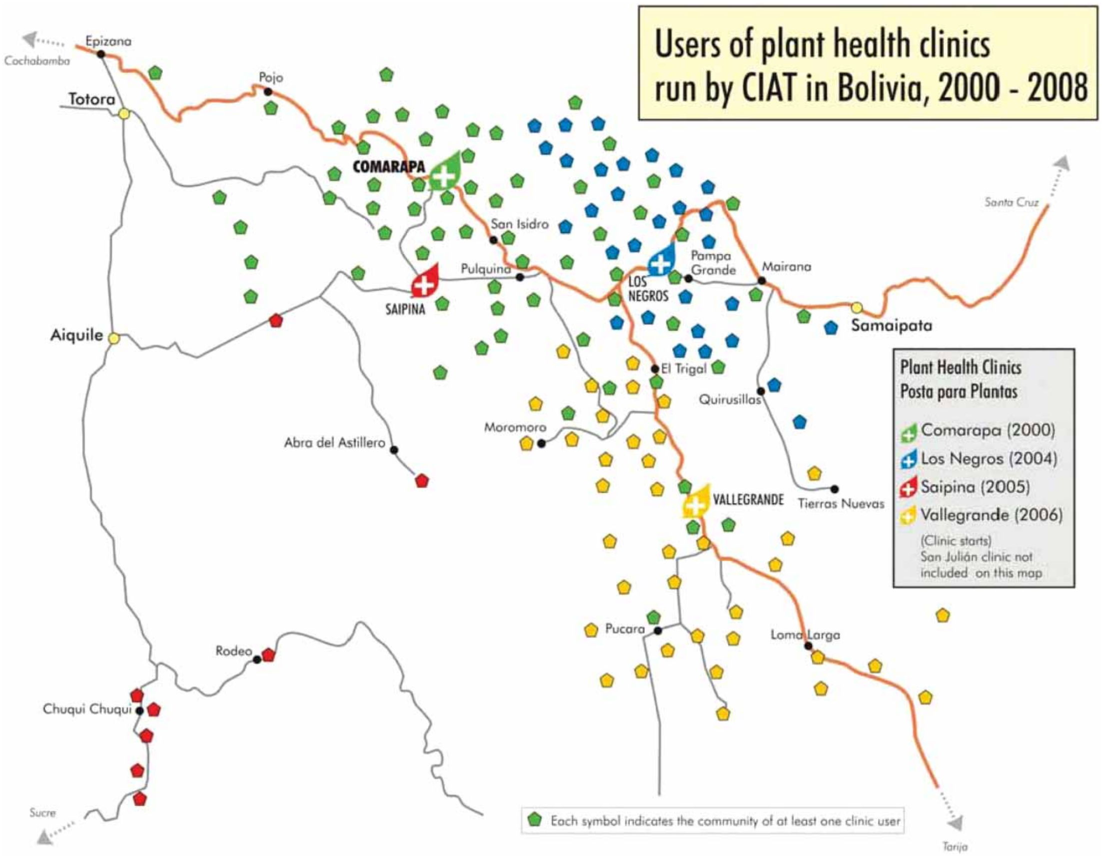

Figure 7 | Locations of clinic users' communities in Santa Cruz

mostly for citrus (41 per cent) and peach palm (22 per cent), while queries from the Valleys of Santa Cruz were for fruit (e.g. peach 14 per cent, strawberry 19 per cent), vegetables (21 per cent) and potatoes (16.5 per cent).

The poor were as likely as the medium group to make repeated visits to the clinic, suggesting that they found the service useful and that they felt welcome (Figure 8).

The clinics helped farmers save money by reducing pesticide use, especially for fruits and vegetables (where the wrong chemical was often applied at the wrong rates). The poor were the most likely to save money by visiting the clinic (Figure 9). However, potato, peach palm and citrus growers tended to spend more when adopting the clinic's recommendations, in part because they were using little pesticide to begin with on these crops. The cost increase was usually modest. For example, following a visit to a clinic, potato farmers might buy 3 litres of insecticide instead of 2, but apply them early in the season, at the base of the plant, instead of spraying the entire plant late in the season. As a result, far fewer potatoes were destroyed by weevils.

Net income gains for clinic users

Discounting cases with incomplete data and crops with fewer than six queries, there were enough data to calculate the net income change for 176 farmers who consulted the clinics for problems with potatoes (Andes and valleys), tomato, strawberry and peach (valleys) and citrus (Chapare and valleys) (Table 5). As for each farmer surveyed, we calculated the change in income due to adoption of the recommendations given for just one of the crops queried. The net change in income is the change in the value of the harvest minus the change in plant protection costs. Of the farmers surveyed, only 25 (11 per cent)

Table 4 | **Clients queried different crops in the three study areas**

Crop	Andes (# queries)	Chapare (# queries)	Valleys (# queries)	% Of crops consulted by interviewees	% Of crops consulted at all clinics to 2009
Potato	114	0	17	54.2	69.7
Tomato	0	0	24	8.8	4.3
Strawberry	0	0	18	7.6	0.2
Peach	0	0	14	5.9	4.3
Citrus (orange, mandarin)	0	15	0	4.6	1.3
Peach palm	0	6	0	2.5	0.4
Bell pepper	0	0	5	2.1	2.4
Pea	0	0	5	2.1	0.4
Other crops (1 or 2 queries)	1	6	13		
Total	115	27	96		

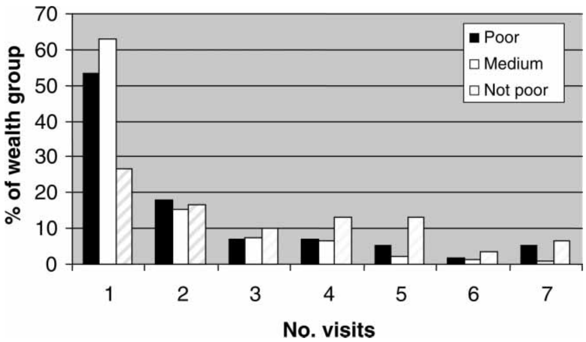

Figure 8 | Percentages of first and multiple visits by farmers in different well-being groups

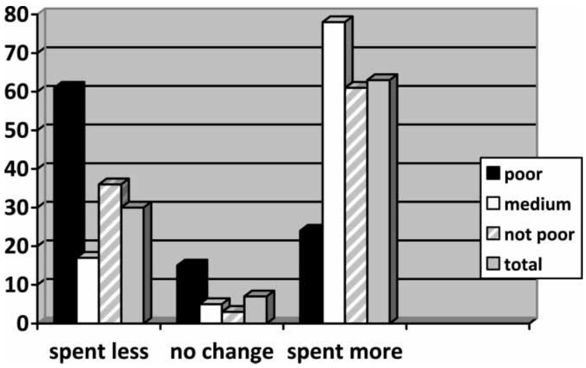

Figure 9 | Changes in crop protection costs according to well-being status (percentages of farmers surveyed)

did not adopt the recommendations (Table 5). Only 19 farmers had a net loss in income after consulting the clinic, while 76 had a net gain in income.

The surveyed famers queried the clinics for 48 different problems on potato, tomato, strawberry, peach and citrus. Nearly half the sampled farmers had come to the clinic with more than one problem per crop (Table 6). As for all major crops except citrus, most of the farmers' queries were for high-impact problems that could cause high yield losses, but which could be treated in one growing season (Table 6).

Potato and tomato faced the greatest threat from high-impact pests and diseases. Andean potato farmers struggled with two devastating insect pests: the Andean potato weevil and the tuber moth (several species of each one). The weevils were so serious that many farmers were considering emigrating or abandoning potatoes. The clinics recommended a pragmatic blend of cultural controls and limited use of insecticide early in the season, thus allowing dramatic increases in production with slight increases in plant protection costs. Most farmers surveyed adopted these functional recommendations (Tables 7–9). Potato results are shown separately from those of the other four crops.

The mean return in the case of adopters of potato recommendations was $691 per hectare (Table 7). This was higher than the returns reported ($100–$536 per hectare) by Ortiz *et al*. (2009) for the impact of IPM training of potato farmers elsewhere

Table 5 | **Changes in income, related to changes in plant protection costs and value of harvest**

	Incomplete data	Harvest value decreased	No change in harvest value	Harvest value increased	Total
Plant protection costs decreased	**1**	**1**	**4**	**56**	62
No change in plant protection costs	3	0	11	**13**	27
Plant protection costs increased	4	*6*	*13*	**110**	133
Total	11	7	28	178	222

Italic values indicate net income loss. Bold values indicate net income gain. Twelve cases are omitted because of missing data.

Table 6 | **Number of plant health problems per client on five major crops, consulted by 176 interviewees**

Crop (# farmers)	Farmers with one problem per crop	Farmers with >1 problem per crop	# Of distinct health problems	Total problems consulted	% Of high impact problems	Examples of high impact problems[1]
Potato ($n = 104$)	55	53	11	168	95	Tuber moth, weevil early and late blight, nematodes
Tomato ($n = 24$)	17	7	12	33	94	Bacterial wilt/canker, mildew, TSWV (tobacco spotted wilt virus), mites
Strawberry ($n = 18$)	13	5	8	22	73	Botrytis, spider mites, Phytophthora root disease
Peach ($n = 12$)	9	3	9	15	75	Brown rot, fruit fly, leaf curl, powdery mildew
Citrus ($n = 14$)	9	5	8	20	25	Aphids, Phytophthora-like root and trunk diseases
Total ($n = 176$)	103 (59%)	73 (41%)	48	258		

Plant health problems include pests, diseases and abiotic disorders.
[1]High impact problems were those that caused heavy damage, but solutions existed that could improve yields in one year. These problems excluded potentially serious diseases such as phytophthora-like root problems in citrus and crown gall in peach, both of which should be managed in advanced infections by replanting.

in the Andes. However, as Ortiz *et al*. correctly observe, the Andes have highly variable ecologies. Studies with lower returns were those of subsistence farmers in marginal areas (O. Ortiz, personal communication). In this part of Andean Cochabamba the weather is ideal for potatoes, the soil is fairly deep and nearby cities provide ready markets for high-quality produce, but the Andean potato weevils were responsible for severely depressing yields. Farmers in Cochabamba reported planting about 10 *cargas* of seed (about a ton) per hectare with a potential yield ratio of 1:10 (i.e. about 10t/ha), which is high for Bolivia but that would be considered low in Europe or North America. With an estimated farm gate sale price of 150 Bolivianos ($21) per *carga*, 10 tons of potatoes are worth $2100. Weevils are capable of causing losses of $691.

To a Bolivian potato farmer, $691 is a lot of money, (Table 7). In Bolivia the average income per rural worker is 460 Bs ($66) per month (INE 2010). Successful farmers earn more than the average rural worker, but an increase of $691, in the case of most

Table 7 | **Change in mean net income after adopting clinic advice for potato problems**

	Adopters
Interviewees with full data available ($n = 104$)[1]	95
Mean area planted in ha (standard error)	1.31 ($\pm$0.09)
Mean net income change per ha	$691
95% confidence interval for mean net income gains	552–845

[1]Full data: area planted, plant protection costs and harvests before and after use of clinic advice; and the nine non-adopters were omitted from the analysis.

farmers, is still about a third of their net receipts from potatoes.

All of farmers surveyed followed the clinic's advice concerning tomato, strawberry and peach. The mean net income gains *per hectare* were an impressive $2704, $2362 and $6494 (Table 8). The returns in terms of peaches seem high, but are realistic. These are top quality peaches for the urban market. A hectare can net $10,000 in a good year, and the quality can easily be spoiled by pests and diseases.

Tomatoes and strawberries are also choice commercial crops, but less profitable. Bolivian farmers have planted citrus in many areas and saturated the market; hence citrus is only marginally profitable. Relatively few farmers produce tomato, strawberry or peach, and some devote less than 1ha of land to these crops, so that income gains per household are often less than those shown in Table 8. The range of mean net income gains per hectare is shown in Figure 10.

The effects of additional training

Of the 238 farmers surveyed, 98 had received additional training from PROINPA, CIAT or other institutions. A greater number of clients from the valleys of Santa Cruz had received additional training (Table 9). Every person (100 per cent) who had received additional training adopted the recommendation from the plant clinic; 82 per cent of those without additional training also adopted the recommendations.

Table 9 | **Clinic users who received additional training by study area**

Area (total interviewees)	Sample size	% Additional training
Andes	114	33.3
Valleys of Santa Cruz	97	54.6
Chapare	27	25.9

Farmers who had additional training gained significantly higher net income increases than did the others ($p > 0.0024$) (Table 10). However, even those who only visited the clinic reported earning an average increased income of $392.

This paper is based on a longer impact assessment of the plant health clinics, titled 'Bigger Harvests in Bolivia', by J. Bentley, E. Boa, F. Almendras, O. Antezana, O. Díaz, P. Franco, F. Franco, F. Ortiz, S. Muñoz, H. Rodríguez, J. Ferrufino, B. Villarroel and E. Iquize, where methods and results are explained in more detail. The full report is available upon request, from either Eric Boa or Jeff Bentley.

Discussion and conclusions

It is difficult to represent the impact of any IPM extension programme (Bentley, 2009a, b); studies usually reveal high rates of return on extension, often over 500 per cent (Davis, 2008). It is one thing to show that farmers have improved their incomes and

Table 8 | **Mean change in net income after adopting clinic advice for four crops**

Crop	Tomato	Strawberry	Peach	Citrus
Number of cases with full data available[1]	20	16	10	12
Mean area planted in ha (standard error)	0.76 ($\pm$0.07)	0.52 ($\pm$0.06)	0.71 ($\pm$0.33)	1.9 ($\pm$0.38)
Mean net income change per ha	$2704	$2362	$6494	$85
95% Confidence interval for mean net income gains	1390–4648	1215–3481	3158–10,420	4–203

[1]Full data: area planted, plant protection costs and harvests before and after use of clinic advice. Areas of peach and citrus are derived from the number of trees owned by farmers. There is some annual variation in the amount of land is for the second year.

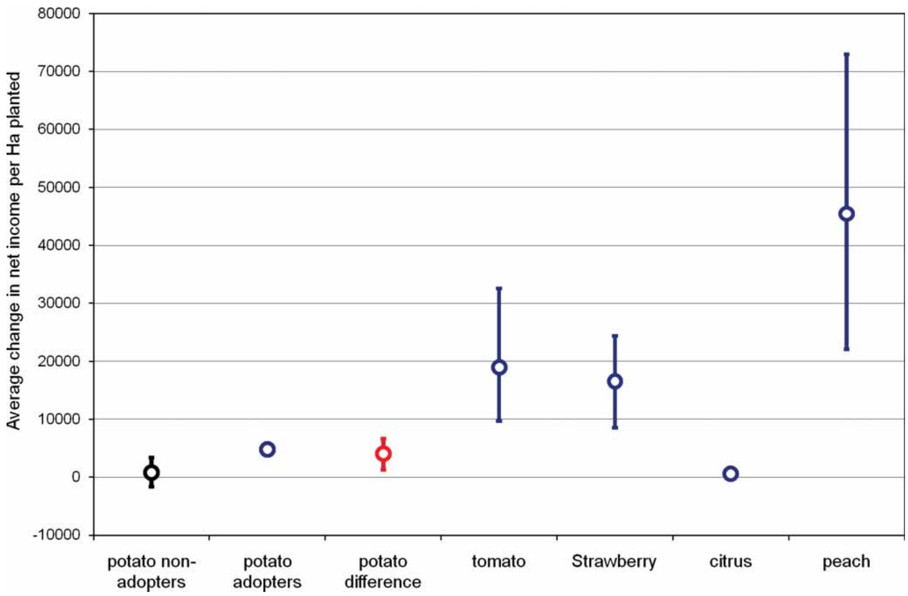

Figure 10 | Estimate of average change in net income per hectare of production

Table 10 | **Average income gain, in one year, for people with and without training**

Clinic users	Sample size	Net income gain
No additional training	132	$392
Additional training	91	$991

another to attribute the earnings to the programme. The farmers who visited the plant clinics also had other sources of information, such as media, neighbours, personal experience, salesmen and extensionists. The most innovative farmers are also more likely to join a group, take a course or visit a plant clinic. This self-selection introduces a bias into impact studies.

Most of the farmers surveyed reported higher yields and better quality produce, which they attribute to extension and to the plant clinics. Almost all farmers adopted the clinic's recommendations and continued to use them year after year. This suggests that the recommendations were profitable (Norton and Swinton, 2008).

At the start of the survey, we hypothesized that the plant clinics helped farmers save money, by helping them avoid needless pesticide applications, but some farmers actually spent more on production. Others did save money, especially in the valleys of Santa Cruz, where pesticides for vegetables were often excessive, expensive and not always effective. The plant clinics contribute to agricultural sustainability by encouraging lesser use of pesticides.

After visiting the plant clinic, most farmers in the Andes of Cochabamba spent a little more on pest control, because they had been spending little to begin with. But their small investments (especially to control the Andean potato weevil) helped them to reap much larger harvests. The clinics in Bolivia recommended essentially the same technologies as did the IPM programme in Ecuador, as described by Mauceri *et al.* (2007), for the same three pests: Andean potato weevils, tuber moths and late blight. Increased yields also lessen pressure on the land. Increasing incomes allows farmers to invest more in their land, adding value to it for the next generation of farmers.

The plant clinics in Bolivia later inspired others in Nicaragua, Bangladesh, Uganda, Vietnam, Nepal and elsewhere, with technical support from the GPC. There are other networks of diangostic clinics elsewhere, but the GPC network of plant clinics is the only one for smallholder farmers in tropical countries (Miller *et al.*, 2009).

Although this survey may lack the statistical certainty of a rigorous impact assessment, the study data suggest that the clinics can make large contributions to farmers' earnings; we were surprised by the high net income returns.

We were fortunate to have had excellent interviewers. Some of the farmers already knew and trusted them. We were not fishing for high numbers; on the contrary, we systematically underestimated economic returns from the clinics in several ways:

- We used low farm gate prices for farmers' products.
- We ascribed only one year of benefits, from recommendations, to farmers, even if they had used our advice for several years (and they usually had).
- We tallied the benefit only in terms of one crop, even if the farmer had consulted the clinic for several.

Bolivian farmers benefited immensely from the clinics. The plant clinics contributed to the adoption of technology, which has been profitable to the farmers.

The plant clinics are not quite traditional extension, because the clinics place more emphasis on the farmers' visiting extension personnel (clinic staff) than the other way around. These plant clinics are not overtly participatory either. According to anthropologist David Mosse, farmers are not especially interested in participating, but do want to improve their farms and their incomes (Mosse 2005).

The plant clinic staff respect farmers and the social difference between them and family farmers is often slight. Many of the elected officials who support the plant clinics are farmers themselves. Most of the agronomists are from small towns. One person who runs a plant clinic is married to a farmer. The plant clinics are demand-driven and interactive; the farmer chooses to start a relationship with the clinic and makes the final decision as to how or whether one should adopt the clinic's recommendations. The farmers are the centre of the plant health system, demanding attention, receiving it and interacting with their service providers in a meaningful way. One reason the clinics have a high, positive impact is because the clients come to them, looking for a specific answer; thus, they are especially receptive to the advice given.

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Appendix A: Impact Study Questionnaire, Plant Health Clinics, Bolivia 2009

1. Nombre		4. Encuestador	
2. Código		5. Fecha	
3. Comunidad		6. Municipio	
7. Código(s) de bitácora			
8. Recomendaciones según la bitácora			

9. ¿Qué le recomendaron en la posta?
10. ¿Qué hizo?
11. ¿Por qué lo hizo así?

12. Recibe capacitación además de la posta?	No		Sí, de CIAT		Sí, de Sedag		Sí, de DSA		Sí, de Proinpa		Otro	

13a. Costos de producción antes de usar la recomendación	13b. Costos de producción con la recomendación
14a. Cosecha antes de usar la recomendación	14b. Cosecha con la recomendación

15. ¿Cómo supo de la posta?	radio		tele		amigo		directo		otro	

16. Nivel de bienestar	1		2		3		otro	

17. ¿Cuántos años usó la recomendación?
18. ¿Por qué lo sigue usando? O ¿por qué ya no lo usa?

Appendix B: English version of the survey form

1. Name		4. Interviewer	
2. Code		5. Date	
3. Community		6. Municipality	
7. Codes(s) from clinic log			
8. Recommendations according to the log			

9. What did they recommend to you in the plant clinic?
10. What did you do?
11. Why did you do it like that?

12. Receives additional training besides the clinic?	No		Yes, from CIAT		Yes, from Sedag		Yes, from DSA		Yes, from Proinpa		Other	

13a. Production costs before using the recommendation	13b. Production costs with the recommendation
14a. Harvest before using the recommendation	14b. Harvest with the recommendation

15. How did you find out about the clinic?	radio		TV		friend		direct		other	

16. Level of wellbeing	1		2		3		other	

17. For how many years did you use the recommendation?
18. Why do you still use it? Or why do you no longer use it?