Impact Assessment of Farmer Field Schools in Cajamarca, Peru:

An Economic Evaluation

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Executive Summary

Economic evaluation of the Farmer Field Schools (FFSs) in the Cajamarca Department (Peru) was undertaken to help determine whether agricultural extension via FFSs can contribute to poverty alleviation. Farmer Field Schools involving a number of important crops have already been evaluated at other sites around the world. These studies reported benefits associated with Integrated Crop/Pest Management (ICM/IPM), such as the reduced used of insecticides, for example. However, the use of ICM/IPM to control potato late blight (the purpose of the Cajamarca FFSs) is quite a complex subject.

In Cajamarca, it was found that only a few components of ICM/IPM have been adopted, despite the education received by the project participants. However, any assessment of the project must also take into account the existence of subtle changes in the cropping techniques used which could not be measured by our surveys, but which are known to have occurred because of positive economic effects observed to have benefited the farmers involved in the FFSs studied. An analysis of consecutive survey data covering up to four years allowed us to identify additional benefits at the farm level through increased yields. Despite these benefits, however, it was noted that the economic returns obtained per household at the sites studied are relatively low, due to the limited average area (0.2 hectare per farm) cropped with potato each year.

The study was unable to confirm the following benefits, which were originally expected to result from these FSSs:

- Reduction in the use of pesticides - Only in one of the four years considered could a statistically significant reduction in the application of pesticides by the participants be proved to have occurred. Differences in spraying frequency seem to be highly dependent on the climatic conditions of the year. The reduction of 0.8 applications which was found to occur in that one year did not represent a significant reduction in cost. With application costs of US$20 per hectare, the average benefit for the participants (with an average potato area of some 0.2 ha each) in the specific year identified was only around US$3.
- Reduced applications of very toxic pesticides - With the exception of the banned, very toxic insecticide Aldrin, no significant changes were found to have occurred with regard to the use of toxic pesticides. The percentage use of those products that fell within

specific toxicity classes was the same among project participants and non-participants, i.e. the two groups used almost the same percentages of very, moderately and mildly toxic products. However, it was found that project participants no longer use Ridomil (metalaxyl). This indicates that they have taken note of, and acted upon, what they learned about the issues of disease resistance in the training.

The only benefit resulting from Farmer Field Schools that was found to be statistically significant was an increase in yield. This increase resulted both from the introduction of a new variety ('Amarilis') and from an increase in farmers' knowledge as result of the education they received in FFSs. As the yield increases were not due to any change in costs or managerial changes, the reported yield increase equals the net benefit obtained.

- **Benefits of a new variety**: The difference in yields generated by replacing one of the other main varieties ('Liberteña', 'Canchan', 'Yungay') with 'Amarilis' is 4 tonnes per hectare per year on average, which means an additional benefit of US$350/ha. Even though the adoption rates among non-participants in neighboring sites were not very much lower than those among participants, this benefit can be, at least partially, attributed to the FFSs, as seed flow was definitely initiated through the FFS project. In villages further away from those taking part in the FFSs, the variety 'Amarilis' is unknown. This effect may become stronger in the future, when some of the clones introduced are also disseminated.
- **Benefits of education**: The additional independent yield effect associated with participation in the FFS, but not due to the variety 'Amarilis', is the result of the knowledge gained by the farmers, and was calculated to be almost 2.7 tonnes/ha on average ($p < 0.05$), an additional benefit of about US$236/ha.

In terms of our economic evaluation of the project, when all benefits are considered (including the effects of education effects and the yield effects resulting from the use of 'Amarilis', in the fields of participants and non-participants) the net present value (NPV) for this CIP/CARE Pilot project reaches US$84,190. The internal rate of return (IRR) is 31%, which is a very healthy basis for investment.

However, concerns exist as to whether the benefits of the introduced variety ('Amarilis') can be attributed to the FFS. If they can, then the question of how much credit is due to the breeders, and how much to the extension system, remains a point of debate. And if yes, what is the merit of the breeders and how much is the merit of the extension system?

On a more positive note, there also exist good reasons to assume that project costs would be lower for future schools, as the conceptual costs and the costs of developing a manual would not be incurred when replicating the project. Therefore only operational costs and monitoring costs are of importance when comparing this project with other projects or when considering the cost of future, similar, projects. In such a case, the project may be judged cost-effective even when the benefits arising from the introduction of a new variety ('Amarilis') are not considered, with only the increase in yields arising from education in FFSs being attributed to the project. Using these assumptions the project achieved an **NPV** of **US$40,270** and an **IRR** of **28%**.

Of course, as the benefits are based on the increase in yield per unit area, it can be concluded that the larger the average potato area of the participating farmers, the more profitable the FFS project will be. In areas where potatoes are grown more commercially, and/or where slightly higher prices are received by the farmers, the additional benefits will be much higher. Therefore, such projects would provide a greater 'pay back' than the project which is the subject of this study.

One factor that may limit these theoretically promising results is the low and volatile market price available for potato in Peru. Because of this, farmers in remote areas (such as the San Miguel sites in Cajamarca) use potato as a subsistence crop, continually reducing their potato area and increasing dairy production when possible. It should therefore be noted that, if the FFS projects were successfully and extensively scaled up, potato prices might decrease as the supply available to an already-saturated market increased. As a result, farmers would have less incentive to produce and sell potatoes.

In the middle and long term, therefore, the benefits farmers receive from such projects in terms of "empowerment" and an increase in their decision-making capacities should be considered to be at least as important as the additional yields they benefit from. Many farmers seem to use what they learnt in the FFS for other purposes in their daily life. This apparent increase in social capital as a result of participatory teaching and capacity building therefore needs to be measured, and is the subject of ongoing work.

Impact Assessment of Farmer Field Schools in Cajamarca

An economic evaluation

Introduction

Potato Technologies and Peru

As a CGIAR Center, the International Potato Center (CIP) works both to fight hunger and alleviate poverty through its agricultural research activities. The Center works mainly with potato and sweet potato, and was originally intended to generate widely applicable technologies that, with some adaptation by national agricultural research systems (NARS), could be extended to farmers and widely adopted (Thiele et al., 2001b). Though based in Peru, the results of CIP's work are useful throughout the world: the majority of potatoes are, for example, grown in Asia and Europe (China and Russia). Of course, CIP's research is very important for its host country too: potato crops originated in the highlands of South America and remain one of the most important food crops grown by farmers in the Peruvian Andes.

Earlier impact evaluation studies evaluating the potato-related technologies produced by CIP have shown very positive results (see, for example, Rueda et al., 1996 and Walker et al., 1996). Such studies have, however, been conducted in the context of countries with a high demand for the crop concerned and a need to increase their food supply. In Peru the situation in the potato sector is different, because the potato market is almost saturated. But, even so, an impact study considering CIP projects in Peru has shown them to be both very promising and successful (Fonseca et al., 1996). Potato production in the country in general, as well as productivity per hectare, has grown continuously and considerably over the last 10 years (Fig. 1). This has, of course, affected potato prices, which have dropped as a result (Fig. 2).

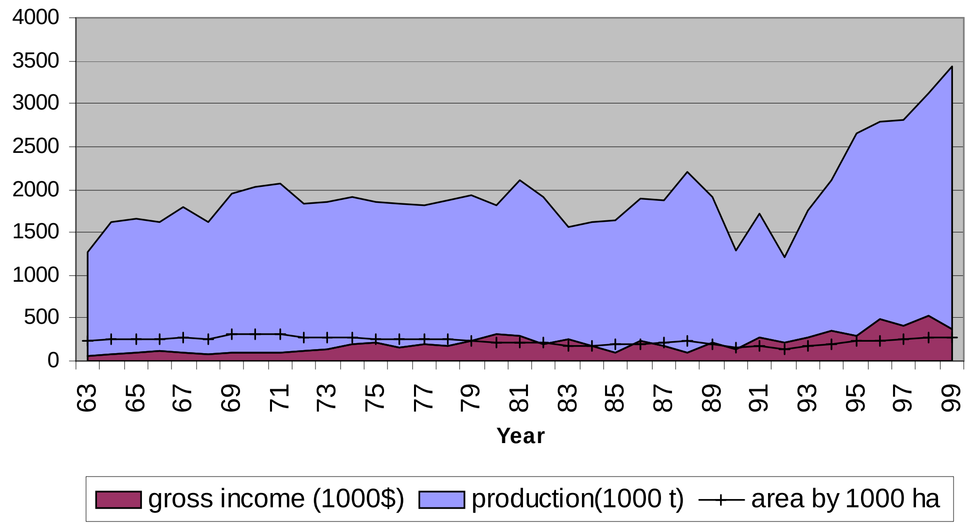

Figure. 1. **Increases in potato production, potato growing area, and market value of potatoes produced in Peru**

(Data from the Peruvian Ministry of Agriculture, MINAG, and the Banco Central de Riserva)

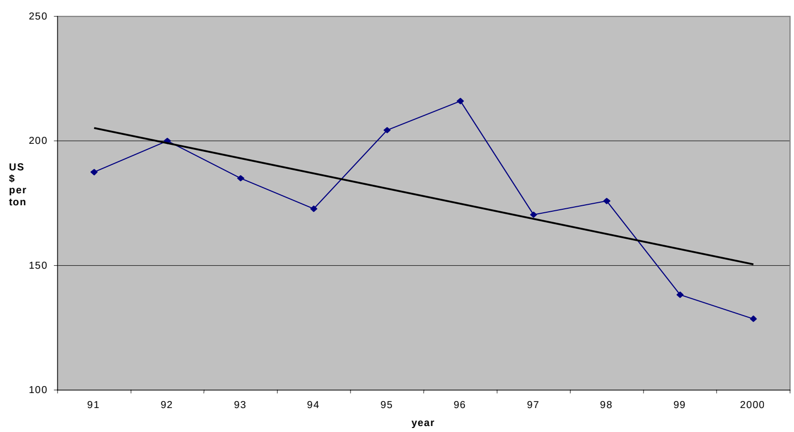

Figure 2. **Real potato prices in Peru**

(Data from the Peruvian Ministry of Agriculture, MINAG, and the Banco Central de Riserva)

Farmer Field Schools

Farmer Field Schools (FFSs) were first used in Asia in the 1980s to train rice-producing farmers in the techniques of Integrated Pest Management (IPM), mainly in order to extend their knowledge of insect pests and to reduce their dependency on insecticides. Now successfully introduced into various countries around the world, such field schools use discovery-based learning methods to improve farmers' agro-ecological knowledge and their capacity to make decisions (van de Fliert, 1993).

The FFSs developed by CIP (in Peru) were to be vehicles for the simultaneous promotion of the integrated management of late blight, the evaluation and dissemination of resistant varieties, and the gathering of large amounts of data concerned with the effectiveness of resistance in different agro-ecologies (Thiele et al., 2001a, Nelson et al., 2001a). In fact, with regard to both CIP's projects and those of other CG Centers around the world, several projects now focus on the use of IPM or Farmer Field Schools or a combination of both. These FFS have already been the subject of several technical evaluations, most of which have demonstrated promising results (van de Fliert et al., 2001; Dung, 2003).

However, there exist serious reservations as to whether FFS projects are an economically viable participatory research and extension method. (Feder, G. et al. 2003) This study therefore evaluates the efficiency and cost-effectiveness of the Farmer Field School approach. It is an *ex post* evaluation of the economic impact of the IPM Farmer Field Schools in the Cajamarca region which (1) verifies all benefits at the farm level and (2) considers the institutional cost-effectiveness of the whole project. The focus placed on other impacts is limited. Impacts on consumers, for example, are not included, because the outreach of the project did not have any consequences for the supply of potato.

Subject of the study

The Farmer Field Schools evaluated in this study are a pilot project, situated in the Province of San Miguel, Department of Cajamarca, in the Northern Andes of Peru. The majority of the farmers in this area grow potatoes for their own consumption and, to a lesser extent, as a cash crop. However, they consider the prices they receive for the potato crops they grow to be too low to provide an incentive for them to invest in the crop. Still, though the commercial possibilities of the crop are limited in these remote sites, almost everybody grows potatoes, which are part of both the regional culture and the people's daily diet.

The Andes in this part of Peru are steeply sloped; the terrain is hilly and the precipitation levels high. Altitudes in the zone included in the different surveys range from between 2700 m to 3500 m above sea level. None of the villages considered by the survey had electricity, though almost three-quarters of their households have access to drinking water, with outlets being situated in front of, or near to, their houses. Depending on the community and whether it has benefited from NGO or government projects (FONCODES) in the past, households may also have latrines (DHS survey: DHS, 1996; Vols.113, 114, 116, 119).

Frost, drought, and floods often threaten the local farmers' harvests; but, generally, the worst enemy of the farmers' potato crops is late-blight infestation, caused by the fungus *Phytophthora infestans* (Ortiz et al., 1999; Troost, 2000). Late blight can be an extremely destructive potato disease, especially in the rainy season. It is one of the most important constraints to potato production, both in Peru and in other countries. An increase in disease severity can rapidly result in a significant yield decrease, often leading to complete crop loss. Unfortunately, over the past few years, some old varieties used in Peru have lost their resistance or tolerance to the pathogen. This problem is compounded by the fact that the Peruvian populations of *Phytophthora infestans* have become resistant to a group of fungicides containing metalaxyl (Nelson et al., 2001a).

The FFSs undertaken in Cajamarca were intended to address the above problems. Eight field schools were initiated in 1998, as part of a joint effort on the part of CARE Peru and CIP. In 1999, 13 schools were operating; this number rose to 20 in 2000, and fell to 16 in 2001. Specifically, the field schools were initiated to improve the situation of poor farmers, by introducing late-blight-resistant potato cultivars and knowledge of IPM/ICM (integrated pest management/integrated crop management). At the same time CIP, as a research center, was interested in evaluating promising clones at an early stage in the selection process. CARE was responsible for the implementation of the FFSs while CIP led the development of the training curriculum, the delivery of clones and cultivars, and the monitoring of data generated by the participatory research (Thiele et al., 2001, Nelson et al., 2001).

The goals of the project were:

- To evaluate and disseminate late-blight-resistant clones and varieties
- To facilitate the dissemination of information about late-blight management
- To enhance farmers' abilities to make better decisions concerning pest control
- To contribute to improved potato management in general
- To help scientists better understand the farmers and the agro-ecological conditions they face.

In the first instance, the FFS approach used had to be adapted to work with potato-related problems as, prior to this, the FFS participatory research and training method had mainly been used in rice-based cropping systems and in different geographic and agricultural circumstances. In the case of the Andean potato-based cropping system, a longer teaching period was required, as the cropping season is around 4-6 months, and several potato-related ICM techniques had yet to be tested. (Nelson et al., 2001)

Database

The present evaluation is not based on data from field trials or experimental plots. It only considers the actual achievements attained by farmers in their fields; potential achievements are not considered. Production data were gathered using farm surveys, with the plots considered being randomly chosen. Table 1 lists the surveys undertaken. Some general and descriptive data are taken from other sources and can also be found in Table 1. For the calculation of yields, only data obtained from field measurements was used (no orally reported yields were used in analyses). The balances used were the so-called "romanillas" balances. However, because the same instrument was not used every year, some problems arose in terms of calibration, and had to be addressed by correcting the yields measured in the last survey.

Table 1. Underlying database.

Source of data (and year)	No. of plots	No. of persons	No. of FFS parti-cipants	No. of varieties observed	No. of comm-unities	Leading institution	Details
DHS Survey 1996	n.a.	n.a.	n.a.	n.a.	n.a.	DHS Inter-national	Data on living conditions
Survey 1997 - 1998	131	131	13	36	23	CIP	Very few yield data
Survey 1998 - 1999	486	486	46	38	13	World Bank	Yield data not sampled, oral communication
Survey 1999 - 2000	98	98	41	23	11	CIP	<30% of yield data sampled
Survey 2000 - 2001	165	165	67	34	14	CIP	49% of yield data sampled
Survey 2001 - 2002	157	157	71	28	14	CIP	80% yield data sampled
Group interviews with women groups 2002	n.a.	150-200	n.a.	n.a.	10	CIP	Collection of information on historical changes
Group interviews with local extensionists 2002	n.a.	20	n.a.	n.a.	n.a.	CIP	Evaluation of personal costs, benefits and motivations
Annual FFS Activity Reports 1998 - 2001	n.a.	n.a.	n.a.	n.a.	n.a.	CARE/CIP	Data on FFSs (number of participants, gender, etc.)

n.a. = Data not available.

The data collected on common indicators are summarized in Appendix 1.

Conceptual Framework and Methodology

It has been said that impact assessment gauges the extent to which a program has led to desired changes in the target field and audience. The overall goal of an impact assessment is to determine if, and the extent to which, a program has reached its objectives [*sic*]" (Shotton, 1999). However, this definition of 'impact' is limited, in so far as unintentional consequences are also important. As Rogers (1995) notes, "change agents often assume that adoption of a given innovation will produce only beneficial results for adopters. This assumption is the pro-innovation bias. Change agents should recognize their responsibility for the consequences of innovations that they introduce. They should be able to predict the advantages and disadvantages of an innovation before introducing it to their clients, but this is seldom done [*sic*]."

In actuality, the impact of an intervention may reach much further than originally foreseen, occurring at different levels (micro, meso, and macro) and in different areas (economic, social, ecological etc.). However, the fact that surveys are not designed to identify, in advance, unknown and unforeseen aspects of a project can cause problems. This is compounded by the fact that the time frames of studies are normally far too short to allow researchers to obtain a holistic overview, especially of slow changes. It should also be remembered that, depending on the focus of the evaluators, some impacts are of interest while others are not. For instance, our study of the Cajamarca FFS project did not assess the impact on consumers, because the outreach of the project was considered to be far too small for it to have any influence on potato prices at either the national or local levels. Both those responsible for the project and its donors did, however, expect it to have economic, ecological, and social impacts for the participating farmers.

Our research was built on quantitative survey data, but not experimental methods, and it was decided, after considering several other possible approaches (Garzalho and White, 1997, Backhaus et al., 2000; Kuckartz, 1999), to use the following methods of quantitative measurement and analysis: correlations, t-tests, regression analyses and cost/benefit analyses.

Therefore, data on the following indicators, covering several years, were analyzed: (1) changes in the varieties used; (2) increases in farmers' knowledge of IPM; (3) implementation of IPM practices (alternative insect control methods, repellents, hilling, planting distance, spraying frequencies, reductions in the amount of toxic products used); (4) increase in yield; (5) better use of protection when applying chemicals, etc.

Correlations, averages, t-tests

As data from before and after project interventions were not available in all cases (to allow before-and-after comparisons) and because the same type of data were not available for every year, annual correlation analyses were used to allow the comparison of participants and non-participants in the FFSs (a 'with' and 'without' comparison). For that reason, correlation analysis was used to determine whether the variable 'participation' was correlated with other parameters (for example 'yield', 'spraying frequency', 'plant distance', 'hilling method', etc.). Furthermore, t-tests were used to confirm whether differences in the average values of these parameters (between FFS participants and non-participants) were statistically significant. Calculations were made using Excel and SAS software packages.

These preliminary analyses provided only a very few positive/conclusive results. The only economically important impact was the fact that yields increased; therefore, this variable was used in a number of further analyses (listed below), which used data from as many years as possible, and which thus aimed to overcome the problem of lack of significance which was assumed to result from the great variation which occurred in study sites (altitude, geographic exposure, etc.), between years, and in the potato varieties used. The following methods were used as the second step in the analysis of the data we obtained:

1. A linear regression model was used to examine which variables contributed independently to the dependent variable yield (y) and, if they did contribute, the extent of that contribution.

2. T-tests were used to quantify and confirm any significant contributions/differences found.

3. If effects of the Farmer Field Schools were confirmed, then the results were monetarized and additional benefits at farm level were defined.

4. The net present value (NPV) and the internal rate of return (IRR) of the FFS project over the years were calculated using the additional benefits identified at the farm level and the project costs. This allowed the cost-effectiveness of the project to be assessed, and enabled us to compare it with other projects.

Linear regression model

A linear regression model was used in data analysis, because data on all possible variables that could affect yield were not available for all years or, if available, were not of a comparable quality. Such incomplete/non-comparable data included data concerned with altitude, geographic exposure of the respective potato plots, fertilization levels, and pesticide applications. Therefore, fertilization effects, for example, were not included even if the surveys with the relevant data showed obvious correlations between yield and fertilization levels (mainly N though, to a lesser extent, P as well). No differences were found between project participants and non-participants with regard to fertilization. This is possibly because fertilization was not treated as a major issue in the curriculum of the potato farmer field schools.

Thus, in the regression model used, the dependent variable ‘yield’ was explained only as a function of the following defining variables: ‘variety’ (var), ‘community’ (com), ‘year’ (year 2 = 2000, year 3 = 2001, etc.), and ‘participation in an FFS’ (eca). The regression model used only includes those data sets that contain sampled and directly measured yield data (i.e. only data from the three surveys 1999/2000, 2000/2001 and 2001/2002) and those communities where potato is a very important crop and/or potato plots are not very small (no vegetable gardens are included).

Yield data from survey 1 (year 0) were insufficient for inclusion. The data obtained in survey 2 (year 1) were not included either, as they had been gathered by oral communication alone, and thus were deemed not to be sufficiently reliable for use in the regression analyses (actually showing yields to be very much lower than in the other years).

The correction factors ‘EA2’, ‘EA3’, and ‘EA4’ are introduced in order to cope with bias which might occur as a result of a “false” correlation between the growing number of project participants in the samples from one year to another and the increase in average yield obtained over the years. This last phenomenon seems to be due to different measuring methods and doesn’t reflect correctly the increase in yields. The regressions were computed using the SAS software package (Box 1).

Box 1. Regression model, and variables used in the SAS analysis package.

Dependent variable:	y	=	yield
Independent variables:	anospart	=	how many years a person had participated (0-4)
	eca	=	whether a person had participated or not (0-1)
Dummies			varieties
	d_var1	=	variety 'Amarilis'
	d_var2	=	variety 'Liberteña'
	d_var3	=	variety 'Canchan'
	d_var4	=	variety 'Yungay'
	d_var5	=	other improved varieties
	d_var6	=	native potatoes
	d_var7	=	clones
Dummies			communities
	d_com1	=	dummy for community 1
	d_com2	=	dummy for…(see Appendix 2)
Dummies	years		
	d_year2	=	dummy for year 2
	d_year3	=	dummy for year 3
	d_year4	=	dummy for year 4
	d_EA2	=	factor for distortions year 2
	d_EA3	=	factor for distortions year 3
	d_EA4	=	factor for distortions year 4 (d_EAX= ECA x d_yearX)

T-tests

As the results of the regression analyses indicated that two variables 'education' and 'variety Amarilis' made a significant contribution to improved yields over the years studied, t-tests were then used to confirm the effects of these two variables. (Appendix 6 and 7) T-tests were used in two ways: (1) to prove that there was a significant difference between the average yields obtained by participants and non-participants, and (2) to prove that there was a significant difference between the average yields attained by 'Amarilis' and those attained by 'other varieties'. The 'other varieties' were considered in the following two ways: (1) as 'all other varieties' and (2) as 'other main varieties' (defined as the simple average of the three varieties 'Yungay', 'Liberteña' and 'Canchan', which are grown almost everywhere in the research site).

Monetarized additional net benefits at the farm level

As no significant changes in practices and inputs were confirmed by preliminary analysis of the survey data and production costs were not affected by participation in FFSs, changes in yield were concluded to equal net benefits. In order to calculate the benefits obtained by each farmer family as a result of the FFSs, the confirmed additional average yield obtained per hectare was multiplied by the average market price paid to farmers in the research site over the last few years (1998-2002) and multiplied by the potato area per farm.

Cost-effectiveness of the project: net present value and the internal rate of return

The total additional net benefits over all participant farmers' fields (calculated as described above) were compared with the overall project costs. Net present values and internal rates of return were calculated for a period of 20 years, assuming (1) an average annual decline of 3.5% in potato prices (see Fig. 2), (2) a discount rate of 10%, (3) no further adoption of the introduced variety after the end of the project, and (4) no spill-over effects of learning to non-participants. Monitoring costs were included, and various scenarios were considered (i.e., including or not including the project's conceptual costs, and including or not including the benefits obtained from the use of 'Amarilis').

Results

According to the survey results, no differences could be identified between participants and non-participants with regard to IPM practices such as changes in hilling intensity, insect collection, the use of traps, the growing of plants that repel insects, etc. Nor were any differences found in terms of the alternation of systemic fungicides with contact fungicides: farmers applied the same fungicide (or fungicide mixture) throughout the cropping season, irrespective of their participation in a FFS. However, several changes in practices may have taken place, but may have been too subtle to be identified by the survey forms and interviewing styles used. Such changes may include, for example, choosing the time at which to spray more carefully, or changes in the way sprays were applied, soil preparation, sowingtechniques and better decisions for timely management in general. (Buck, 2001)

However, comparison of averages and correlation analyses showed that some changes had occurred. We outline these in the sections which follow.

Knowledge

Results from correlation analyses showed that, in both the 2000/2001 and 1997/1998 surveys, FFS participants achieved significantly better results ($p < 0.001$, $r = 0.86$) in knowledge tests (Nelson et al., 2001) than non-participants. Better results in knowledge tests were also found to be correlated with better yields ($p < 0.05$, $r = 0.16$). However, the correlation between participation in FFSs and better yields was not significant.

Pearson Correlation Coefficients, N = 152

Prob > |r| under H0: Rho=0

	yield	FFS	Knowledge
yield	1.00000	0.13003	0.16100
		0.1103	0.0475
FFS			0.86151
			<.0001

(not all of the 165 respondents had made a knowledge test>>>only N=152)

This seems to confirm the contribution that increased knowledge was originally expected to make to yield (Gotland et al., 2002).

Pesticides

Frequency of application

Only in the 2000/2001 survey, the year with the most severe late-blight infection, did FFS-participants apply pesticides significantly ($p < 0.01$) less frequently than non-participants.

Pearson Correlation Coefficients, N = 165
Prob > |r| under H0: Rho=0

	part	noapplictot	uantiyproducts	alternance
part	1.00000	**-0.20072**	-0.01807	0.03015
		0.0097	0.8178	0.7007

The average number of applications of both fungicides and insecticides by participants was found to be about 7 (7.26); the average number of applications by non-participants was found to be about 8 (8.08). Therefore, there was a 10% reduction in the frequency of application, which corresponds to a total cost saving of around US$3 per farmer (see Appendix 3).

Quality of pesticides used

Among FFS participants, a shift was observed away from the use of Ridomil (methalaxyl) to other alternatives. But, no general shift was found to occur away from the use of toxic pesticides towards the use of less toxic pesticides. The only product no longer used (‘mentioned’) by participants was the highly toxic, and officially banned, Aldrin. In some cases, non-participants mentioned that they still use Aldrin, but they often call a pesticide Aldrin when they do not exactly know what it is. However, we were unable to find any actual proof of the use of Aldrin.

User protection

The 2001/2002 survey showed (Table 2) that FFS participants protected themselves better than non-participants when preparing and spraying pesticides (in terms of the wearing of gloves: $p < 0.001$, $r = 0.27$; and, the wearing of protective overalls: $p < 0.01$, $r = 0.24$). However, this could not be confirmed in the case of other survey years.

Table 2. Differences between farmer field school (FFS) participants and non-participants in their protection against pesticides (Source: CIP Survey 2001/2002).

Variable	**FFS**	**Non-FFS**
% of farmers who use some protection while spraying	74%	65%
% of farmers who use some protection while preparing pesticides	18%	2%

Resistant Varieties

Perhaps the most important IPM measure adopted by the FFS participants is the use of late-blight-resistant varieties. The project gave them access to new varieties, which increased the adoption of resistant varieties (such as 'Amarilis') and clones (Fig. 3).

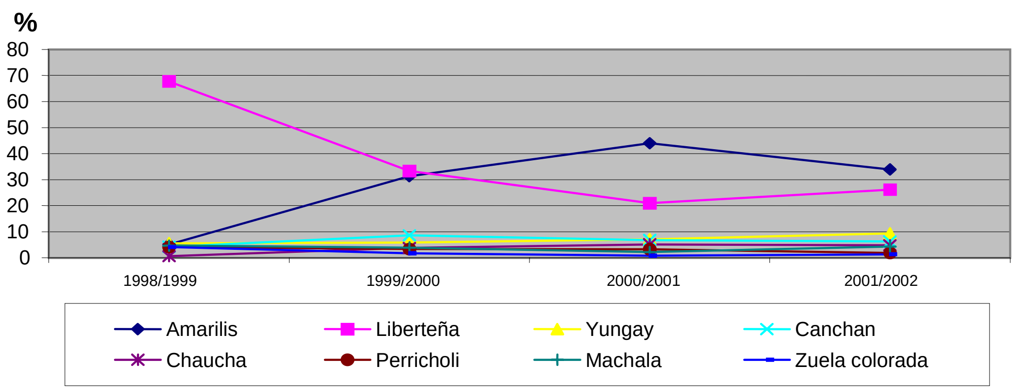

Figure 3. Distribution of the 8 most important varieties in San Miguel 1998-2002 (% of seed planted by all farmers)

With regard to the clones, even though several were much superior to Amarilis with respect to late-blight resistance, they will not be considered further in this analysis as they were only introduced in very small quantities. However, it should be noted that interesting data concerning their adoption may arise over the next few years.

Because of the informal seed distribution system which exists, in which seed is shared with neighboring farmers, the new variety ('Amarilis') was also very quickly adopted by non-participants, though without any additional measures or subsidies (Fig. 4). Despite the massive adoption of a new variety, the farmers who participated in the FFS did not drop the old and prevailing varieties. However, data from the 2001/2002 survey show that participants conserve more varieties than the non-participants (see Appendix 4).

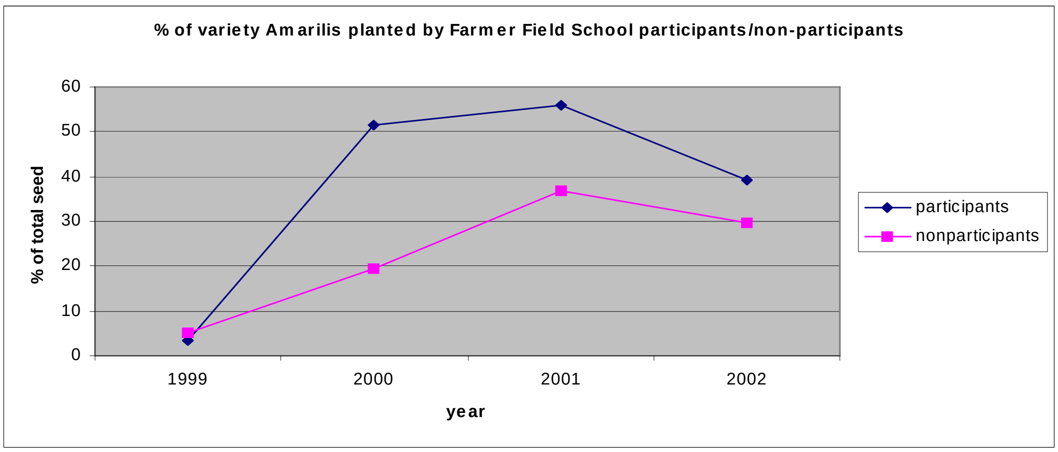

Figure. 4. Difference in adoption of 'Amarilis' between FFS participants and non-participants

Yields

The results obtained from correlation analyses indicated that use of 'Amarilis' and the education received by participants in FFS very probably had a positive influence on the yields farmers obtained. This could not, however, be proved to be statistically significant.

We therefore used a linear regression model to explain the independent contribution of different factors (years, communities, varieties and FFS-education) to the variable 'yield', as explained above (pages 14-16). For details of one analysis see Box 2, and for the output from SAS, see

Appendix 5.

Box 2.
Number of observations: 430
Dependent Variable: yield
Variety of reference (var 2): 'Liberteña' (variety mainly replaced by Amarilis due to similar characteristics)
Community of reference: com 9 (Quilcate, community with a moderate average yield)
Years of reference: 2000 (first calculation) and 2001 (second calculation); data for 2002 was not used, because of the much higher average yields obtained in that year

Regardless of the year of reference (2000 or 2001, see Box 2) the estimates of an independent positive contribution of the factor 'participation in a FFS' ('eca') and of the variety 'Amarilis' ('d_var1') remain significant. The influence of the Farmer Field School ('eca') was significant ($p < 0.05$), as was that of the variety 'Amarilis' ($p < 0.05$).

	Parameter	Estimate	Error	**t Value**	**Pr > |t|**
Base 2001	eca	4.10	1.59	**2.57**	**0.01**
	d_var1	2.35	1.09	**2.15**	**0.03**
Base 2000	eca	6.56	2.68	**2.45**	**0.01**
	d_var1	2.35	1.09	**2.15**	**0.03**

(For details, see Appendix 5)

These results show that 'variety Amarilis' and 'FFS participation' make a completely independent contribution to yield. However, they do not explain how large the average contribution made by each factor is. In the next step, therefore, we quantify the contribution of these two variables.

Economics of Training

In order to quantify the 'education effect' ('eca') of participation in FFSs, a t-test was used to confirm the differences in yields apparent between participants and non-participants, using combined data from the following three years: 2000, 2001, and 2002.

Statistics

Variable	part	N	Lower CL Mean	**Mean**	Upper CL Mean	Lower CL Std Dev	Std Dev	Upper CL Std Dev	Std Err
yield	0	229	16.76	17.799	18.838	7.31	7.98	8.7864	0.5273
yield	1	201	19.359	20.524	21.689	7.6317	8.3785	9.2886	0.591
yield	Diff (1-2)		**-4.277**	**-2.725**	**-1.173**	7.6562	8.1686	8.7552	0.7895

The t-test revealed a statistically significant difference between the means of 2.725 tonnes/ha over the three years ($p < 0.001$; see Appendix 6).

Therefore the positive annual effect on yield of participating in a Farmer Field School is 2.7 t/ha, this equates to about US$236 per hectare.

The average potato price paid to the Cajamarca farmers in the field in recent years has been between US$85 and US$90 per tonne. Considering the additional yield obtained per year (2.7 t/ha), the prices obtained (US$87.5/tonne) and the average potato area per family (0.2 ha), the average additional gain per participant as a result of this FFS project was about **US$47.30** per year. And due to the yield increase there has been a reduction in the cost per unit produced, so the potential competitiveness has increased.

Economics of Variety ‘Amarilis’

As we have seen from the results from the regression model, the positive contribution of the variety ‘Amarilis’ was confirmed to be significant at the 5% level. In order to determine the importance of this contribution to yield we ran two t-tests, one comparing the yield of ‘Amarilis’ with the average of all other varieties (T1) and one comparing ‘Amarilis’ with the average yield of the three other most important varieties (T2). The analysis (Appendix 7) was similar to the t-test conducted for ‘economics of training’.

The t-tests showed an improvement in yield of at least 4 tonnes/ha due to the introduction of the variety ‘Amarilis’. The improvements were 4.4 t/ha and 4.2 t/ha in the cases of T1 and T2, respectively.

This additional yield (4 t/ha) is equivalent to an additional gain of about US$350 per year (given the market price of US$87.50/t). However, farmers do not, and will not, plant their whole potato-growing area with ‘Amarilis’ (they use it on only a proportion of their growing area). On average, among the participants, ‘Amarilis’ made up 39.3% of the total seed used, while among non-participants, this figure was 29.5% of the seed used (data from 2002; Fig. 3). However, farmers’ use of ‘Amarilis’ is declining slightly.

Therefore, in order to be cautious, from this point onwards, the assumptions used in calculations are that the percentages of farmers’ potato-growing areas that are cropped with ‘Amarilis’ are 35% in the case of participants, and 30% in the case of non-participants.

Therefore, with an additional yield of 4 t/ha and a market price of US$87.50/t, the average area of potato grown with the variety ‘Amarilis’ per family (0.07 ha for participants, 0.06 ha for non-participants), would result in an additional benefit (due to ‘Amarilis’) of around **US$24.50** for participant households and **US$17.50** for non-participant households.

Total Costs and Benefits of the Project

Costs

The costs of the FFSs were monitored over several years. The result (an average operational cost of US$70 per participant per year) was only slightly higher than the average operational costs (about US$60 per participant per year) experienced by other FFS projects around the world.

The total cost of the project (**US$97,700; Table 3)** was slightly higher than those of other FFS projects for several reasons:

- Because IPM interventions differ greatly from one crop to another, they needed to be redesigned for this project. Therefore, many technical details of the teaching curriculum had to be developed.
- Because the potato-cropping season is longer than that of rice or vegetables (the subjects of other FFSs) the lessons had to be distributed over a longer period in this project.
- It was necessary for the scientists and extension specialists to write a manual for use with the project—however, this final product can be used for future FFS projects concerned with potato.
- As mentioned earlier, this Farmer Field School project has also had a strong research component, involving the early evaluation of new clones and varieties. Through the participatory involvement of farmers the selection of promising clones could be considerably accelerated (Ortiz et al., 2002).

Table 3. Real costs of the Cajamarca pilot FFS project (source: CIP/CARE budgetary data and Annual FFS Activity Reports).

Year	Number FFS	**Participants**	**Costs (US$)**	Details
97/98	0	0	20,000	Concepts/Manual
98/99	8	**115**	**8,800**	Operational costs
99/00	13	**160**	**14,300**	Operational costs
00/0I	20	**345**	**22,000**	Operational costs
0I/02	16	**274**	**17,600**	Operational costs
			15,000	Monitoring costs
Total			**97,700**	

Benefits

The overall benefit of the project reached in this period is the sum of the following.

1 Benefits from participants through better yields due to

   1.1 Training

   1.2 Adoption of the new variety.

2 Benefits of non-participants through better yields because of

   2.1 Adoption of the new variety.

Benefits 1 (participants)

Year	Number of beneficiaries	Total potato area (ha)	Benefits (US$/ha) due to education	Benefits (US$/ha) due to 'Amarilis'	Total benefits of education	Total benefits of 'Amarilis' 10-50-35%[1] of potato area	All benefits
1998	115	23	0.0		0.0	0.0	0.0
1999	160	32	236.0	350.0	7552.0	1120.0	8672.0
2000	345	69	236.0	350.0	16284.0	12075.0	28359.0
2001	345	69	236.0	350.0	16284.0	8452.5	24736.5
2002		69	227.7	337.8	15711.3	8157.9	23869.2
Total							**85,636.7**

Benefits 2 (non-participants)

Year	Number of beneficiaries	Area (ha) beneficiaries	Benefits (US$/ha) due to 'Amarilis'	% of potato area cropped with 'Amarilis'	Total benefits of 'Amarilis'
1998	115	23			0.0
1999	160	32			0.0
2000	345	69	350.0	10.0	2415.0
2001	345	69	350.0	35.0	8452.5
2002		69	337.8	30.0	6992.5
Total					**17,860.0**

The benefits gained (above) covered the cost of the project, but in order to assess whether the

[1] 10% in 1999, 50% in 2000, 35% in 2001

project would 'pay back' the money invested, the evaluation needs to include the calculation of the NPV and IRR, both of which require a longer observation period. In order to assess the cost-effectiveness of an agricultural project, the minimum timespan required is considered to be 15-20 years.

Cost-effectiveness: Net Present Value and Internal Rate of Return

Deleted: ¶

Table 4. Returns on the Cajamarca pilot FFS project.

Year	Costs/ year (US$)	Number of participants	Total area: participants (ha)[a]	Benefits due to training: participants (US$/ha)	Benefits due to 'Amarilis': (US$/ha)	Area: non-participants (ha) [a]	Total benefits of FFS-training (US$)	Total benefits of 'Amarilis': non-participants (US$)	Total benefits of 'Amarilis': participants (US$)	**Net benefit (US$)**
1997	20,000	0	0	0.0	0.0		0.0	0.0	0.0	(20,000.00)
1998	8,800	115	23	0.0	0.0		0.0	0.0	0.0	(8,800.00)
1999	14,300	160	32	236.0	350.0		7552.0	0.0	1120.0	(5,628.00)
2000	22,000	345	69	236.0	350.0	10.0	16284.0	437.5	13282.5	8,004.00
2001	17,600	274	69	236.0	350.0	25.0	16284.0	2187.5	8452.5	9,324.00
2002	15,000		69	227.7	337.8	50.0	15714.1	4221.9	8156.7	13,092.60
2003			69	219.8	325.9	50.0	15164.1	4074.1	7871.2	27,109.36
2004			69	212.1	314.5	50.0	14633.3	3931.5	7595.7	26,160.53
2005			69	204.7	303.5	50.0	14121.2	3793.9	7329.8	25,244.91
2006			69	197.5	292.9	50.0	13626.9	3661.1	7073.3	24,361.34
2007			69	190.6	282.6	50.0	13150.0	3533.0	6825.7	23,508.69
2008			69	183.9	272.7	50.0	12689.7	3409.3	6586.8	22,685.89
2009			69	177.5	263.2	50.0	12245.6	3290.0	6356.3	21,891.88
2010			69	171.3	254.0	50.0	11817.0	3174.9	6133.8	21,125.67
2011			69	165.3	245.1	50.0	11403.4	3063.7	5919.1	20,386.27
2012			69	159.5	236.5	50.0	11004.3	2956.5	5712.0	19,672.75
2013			69	153.9	228.2	50.0	10619.1	2853.0	5512.0	18,984.20
2014			69	148.5	220.3	50.0	10247.5	2753.2	5319.1	18,319.75
2015			69	143.3	212.5	50.0	9888.8	2656.8	5133.0	17,678.56
2016			69	138.3	205.1	50.0	9542.7	2563.8	4953.3	17,059.81
									NPV	**84,189.33**
									IRR	**0.31**

[a] Assuming 0.2 ha per farmer.

The project may be evaluated in different ways according to the different costs and benefits that can be included:

(1) If we include the overall benefits obtained (1) by participants, as a result of better yields arising from education and the adoption of the new variety, and (2), by non-participants as a result of better yields arising from the adoption of the new variety, it can be concluded that the project shows a very healthy performance, achieving an NPV of about US$84,200 and an IRR of 31% (Table 4). A project with a return to investment of more than 22% is considered to be solid and cost-effective. So, the NPV attained by this project is positive but not very high, which is, of course, due to its limited outreach.

However, there remains the problem of attribution of benefits, in so far as one might argue that the additional benefits participants and non-participants received a result of the introduction of ‘Amarilis’ cannot be entirely attributed to the FFS project, because the FFSs only helped to disseminate the variety and so shortened the adoption time. The breeding work undertaken to produce the variety should also be taken into account when considering benefits and costs. In this case, only part of the additional benefits obtained as a result of the introduction of this variety could be attributed to the project; however, the decision of how much of the benefit obtained could be attributed to the project would, in this instance, be very arbitrary.

(2) If this viewpoint is accepted, in order to ensure that no undeserved benefits are assigned to the FFS project, only the increase in yield that originated from the FFS education should be considered. That is, the increase in yield that resulted from the introduction of ‘Amarilis’ should not be included. Using this approach, the project shows an NPV of about US$18,423 and an IRR of 15%, which is insufficient to justify the project (see Appendix 8).

(3) However, just as one might argue that the variety benefits cannot be attributed to the project, one can also argue that the costs of the conceptual work and the composition of a manual should not be attributed to the project, as they are one-off costs that would not occur should the project be replicated elsewhere. Using this perspective, therefore, which only considers the operational and monitoring costs of the project and the educational benefits received by participants, the NPV is about US$40,270 and the IRR 28% (see Appendix 9).

All estimations are conservative and reliable because they are not based on research trials, as they are in most *ex ante* evaluations, but on measured data from farmers’ fields and on very few and conservative assumptions concerning future development. Additional sensitivity analyses showed that FFS projects would be much more cost-effective if the average potato area per farmer was bigger than in the pilot sites (Appendix 10). However, they also showed that FFSs would not be a very economic method if used solely for the diffusion of a new variety (Appendix 10). Scaling up the projects would require considering future impacts on potato prices and consumers.

Conclusions

The study of the Cajamarca FFS project revealed several interesting findings:

1. It is much more difficult to introduce IPM technologies into potato cropping areas where late blight is endemic than it is to introduce such technologies into other sites and/or to other crops where insects are the most severe pest problem. To date, the opportunities for IPM late-blight management are limited to the use of fungicides and resistant varieties.
2. Better crop-management knowledge does not automatically mean that knowledge is applied in the field or in daily life. On the other hand, learning can affect the skills of participants in ways which are not obvious but which do result in yield increases.
3. In reality, farmers could not monetarize their additional benefits, because potato prices fell by 25% in Peru during the period in which the FFSs were implemented. This had a serious effect, as the cost/benefit relations no longer justified the commercialization of the participants' potato crops. Strong price fluctuations occur in Peru from year to year because of the country's climatic conditions. However, the general trend observed in the price data for the last ten years (Fig. 2) has been a decline in potato prices. The current changes in the behavior of consumers, and the fact that supply will probably continue to exceed demand, make it likely that potato prices will continue to drop.

All this may explain why we were able to confirm only a few of the changes/differences, which were originally expected to result from the teaching of the IPM Farmer Field School curriculum. Even if the knowledge of FFS participants was significantly better than that of non-participants, it was not possible to capture changes of technologies with the survey method. It might have been possible with other, qualitative methods, but almost none of the changes proposed by the curriculum are implemented. Most importantly, they did not significantly reduce their use of pesticides, nor did they adopt any labor-intensive IPM methods. But FFS participants started to protect themselves better when preparing and applying pesticides; this is a positive result, even if acute pesticide poisonings have never been a major problem in the site at which the project took place, probably because pesticide use was always lower in this area than in other areas, where potatoes are grown for sale.

Therefore, the most important outcome is the fact that, despite the lack of any obvious changes in the cropping techniques used, farmers yields were significantly greater (by 2.7 tonnes/ha), as a direct result of the education gained through participation in FFSs.

If the yield benefits given by the introduction of ‘Amarilis’ are included in the budget, this project can be considered to have attained an NPV of US$84,000 and an IRR of 31%. However, if none of the benefits resulting from the introduction of ‘Amarilis’ are attributed to the project, and if all conceptual costs are included in the budget, the NPV falls to US$18,000 and the IRR to only 15%.

In fact, the most reasonable viewpoint to take when comparing the project with others and evaluating its sustainability involves considering only the additional yield benefits obtained by participants as a result of their education, without actually considering the additional benefits resulting from the introduction of ‘Amarilis’. At the same time, initial conceptual costs and the costs involved in compiling a project manual, which should not be considered as they were unique, and would not be incurred should the project be replicated. Such an assessment provides an NPV of more than US$40,000 and an IRR of 28%.

The latter finding shows that the benefits accrued as a result of the project are sufficient to confirm that Farmer Field Schools are an economically interesting way of diffusing IPM technology. The FFS model should therefore definitely be recommended as a viable investment to donors interested in funding similar projects. Our analyses also showed that the cost-effectiveness of the projects, and the economic benefits gained, would be much greater if the area cropped with potato was more than 0.2 ha per participant. Only in the case of schools in which the participants crop a smaller area with potato would the ‘payback’ obtained be negligible.

With regard to poverty alleviation and the justification of similar projects, one might say that any increase in income, no matter how small, benefits the farmers involved. From this perspective, the project did contribute to poverty alleviation, even though the benefits gained have been relatively small so far.

But, despite the cost-effectiveness of the project and the potential benefits for consumers, the question is: how much sense does it make to invest in increasing the production of a crop for which the market is already saturated? Should FFS focus on increasing competitiveness? We must therefore ask: what will happen if the Potato Farmer Field Schools are scaled up to such extent that prices fall due to the increased offer? The answer is that additional benefits could rapidly diminish as a result of price reductions (see Appendix 11).

Of course increased potato production is not the only and ultimate goal of these projects. Farmers learn well in Farmer Field Schools, and there is a real interest among them to learn more. In the San Miguel site, farmers prefer to invest now in dairy production rather than in potato cropping; it should therefore be recognized that the FFS education system could be applied to, and used to improve, many other crops and production systems. In some of the pilot communities the former FFS participants are already using the experience they gained from the potato-FFSs and are continuing the schools on their own initiative. Some of the most skilled farmers had received extra education during the project cycle and are now the new teachers in their community, on a voluntary basis. Some of the experienced FFS groups are choosing to study different crops or subjects and are looking, by themselves, for a teacher or an expert. They now have the skills and knowledge, which enable them to look for support (from NGOs, governmental institutions, etc.) and organize themselves. In some FFS communities, people have initiated community work groups, a tradition, which was practiced previously but had been lost.

Thus it could be concluded that, in the long term, the main benefit of the FFS methodology may not be the direct economic advantage associated with increased potato yields or competitiveness, but the effects such a methodology has on the participants and their behavior, in terms of increasing their enthusiasm and developing their skills. This ’empowerment‘ or ‘strengthening’ of human capital still needs to be measured, and is the subject of an ongoing study. This is measuring differences between the personal development of FFS participants and non-participants, as well as the differences apparent between participants and non-participants in other participatory projects.

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Appendices

Appendix 1

Data collected on common indicators (NB none of the differences in this table are statistically significant; the table simply presents averages, for comparison).

Variable	1998 Participants	1998 Non-participants	1999 Participants	1999 Non-participants	2000 Participants	2000 Non-participants	2001 Participants	2001 Non-participants	2002 Participants	2002 Non-participants
Formal education (average years)	5.2	5.1	6.4	4.6	5.8	5.9	6.2	4.7	6.5	4.6
Average age	44	43	38	44	44	43	38	43	40	45
Assets: cattle (male and female)	3-4		4.6	3.5	5.5	7.4	4.7	5	8	8
Land area (ha)	5	9	13.2	11	6.6	8.5	8.3	9.4	7.7	9.8
Area of potatoes/farmer (ha)	0.51	0.68	0.30	0.27	0.22	0.30	0.20	0.26	0.21	0.22
Yield (t/ha)	n.a.	n.a.	4.9	6.3	10.5	9.9	17.9	16.4	22.7	21.2
Number of pesticide applications/potato crop	7.4	6.7	n.a.	n.a.	5.7	5.9	7.3	8.1	8.4 total (6.7 fungicides, 1.7 insecticides)	8.4 total (6.7 fungicides, 1.7 insecticides)
Application of main pesticides (in 2002 survey, '%' refers to the times included in the application – as farmers mix products, total is > 100%)	Ridomil 31% Antracol 14 % Manzate 10% Tamaron 8% Mancozil 5% (% of total number of applications)		Citowet 23% Furadan 13% Manzanex 11% Mancozil=Manzate 5.5% Brestan 5.4% (% of frequency of being mentioned by farmers		Antracol 21% Mancozil 19% Ridomil 14% Manzate 7% (Monofos insect.) 8% (% of total number of applications)		Antracol 33% Mancozil 22% Manzate 10% Dithane 5% (% of total number of applications)	Antracol 37% Mancozil 26% Manzate 9% Ridomil 8% (% of total number of applications)	Monofos 53% Baytroid 22% Buldoc 9% Parathion 4% Mancozil 39% Manzate 30% Antracol 26% Manganet 7%	Monofos 53% Tamaron 16% Baytroid 13% Parathion 6% Aldrin 5% Mancozil 50% Antracol 45% Manzate 23% Ridomil 11%
Main varieties used (% of seed grown) averaged over all farmers	Libertena 36.6% Canchan 17.5% Amarilis 16.0 % Yungay 13.7 % Pericholi 3.8 % Renacimiento 3.1 %		Libertena 70% Yungay 6% Amarilis 5% Zuela colorada 5% Machala 5% Pericholi 3% Canchan 3% Renacimiento 2%		Amarilis 24% Libertena 16% Canchan 13% Chaucha 8% Yungay 8% Machala 5%		Amarilis 43% Libertena 21% Yungay 7% Canchan 7% Chaucha 5% Pericholi 3% Peruanita 3% Machala 2%		Amarilis 33.9% Libertena 26.2% Yungay 9.4% Canchan 6.2% Chaucha 4.8% Pericholi 1.8% Peruanita 1.5% Machala 4.3%	
Farmers considered in survey	13	118	45	441	41	57	67	96	71	90

Appendix 2

Codes for communities and varieties used in the regression model

Community	Code
Arteza	1
Banos	2
Cortadera	3
Los Angeles	4
Milagro	5
Mutish	6
Pabellon	7
Progreso	8
Quilcate	9
San Lucas	10
Sta. Aurelia	11
Tantachual	12
Zognad	13
Laguna	14
Sta. Rosa	15
Lanchepampa	16
Lipoc	17
Quengo	18
Vitian	19

Variety	Code
'Amarilis'	1
'Libertena'	2
'Canchan'	3
'Yungay'	4
Other improved varieties	5
Native varieties	6
Clones	7

Appendix 3

The data obtained in the 2000/2001 survey showed that, on average, FFS participants made 7.26 applications of pesticide per crop, while non-participants made 8.08 applications, Appendix 1). The difference between the two groups was 0.82 applications, equivalent to a 10% reduction in frequency of application.

Participants were found to spend almost the same amount per application as non-participants (Appendix Table 1). Although the average amount spent by participants was slightly higher (2.1 soles per application, per hectare) this difference was not statistically significant.

Appendix Table 1. Average costs per pesticide application, per hectare (Peruvian soles[a]); data from a survey in 2000/2001.

	Average cost of fungicide + insecticide/ application/ha	Cost of fungicides	Cost of insecticides
Participants	57.6	51.9	5.7
Non-participants	55.5	51.4	4.1

[a] 1 US dollar = 3.5 Peruvian soles (December 2002).

Adding the average costs of labor and hire of spraying equipment (10-12 soles per application), gives a total cost per application of 68-70 soles/ha (US$20/ha). Thus, the average per-hectare saving made by making 0.82 less applications of pesticide (the average reduction noted above) would be only US$16.4/ha (0.82 $\times$20). With an average potato area per farmer of 0.2 ha the average saving per farmer is US$3.28 (0.2 $\times$16.4).

Appendix 4

Quantity of different potato varieties planted (% of seed grown, averaged over all farmers).

Varieties 2001-2002	Participants		Non-participants	
In total, 28 varieties were grown. FFS participants grew 26 varieties. Non-participants grew 14 varieties, which included 2 varieties not grown by participants: ‘Revolucion’ and ‘Colegiala’.	Amarilis*	39.3%	Amarilis*	29.5%
	Libertena	18.1%	Libertena	32.6%
	Yungay	11.2%	Yungay	7.9%
	Canchan	3.8%	Canchan	8.2%
	Chaucha	3.9%	Chaucha	5.5%
	Machala	2.8%	Machala	5.5%
	Renacimiento	1.1%	Renacimiento	2.6%
	Perricholi	2.1%	Perricholi	1.5%
	Atahualpa	3.1%	Atahualpa	0.3%
	Peruana	0.7%	Peruana	2.0%
	Zuela colorada	1.1%	Zuela colorada	1.4%
	Chagllina	0.9%	Chagllina	0.2%
	Clones*	4.3%	Revolucion	1.7%
	Chata roja	2.6%	Colegiala	1.1%
	Belen	0.8%		
	Calabaza	0.8%		
	Shoga colorada	0.7%		
	Huagalina	0.7%		
	Sapa	0.4%		
	Luren	0.4%		
	Tps*	0.2%		
	Huayro	0.2%		
	Maria bonita	0.2%		
	Chiquibonita	0.2%		
	Tomasa	0.1%		
	Luquilla	0.1%		

*Introduced by FFS project

Appendix 5

GLM (general linear regression model) for yield

The standard output from the statistical software package SAS includes an analysis of variance table as well as the Root MSE, the mean of the dependent variable, the coefficient of variation, the R-Square value and the adjusted R-Square. In the ANOVA table, a small *p*-value (listed under the heading "Prob>F") indicates that the model explains a significant portion of the variation in the data. The characteristics of the parameter estimates depend on the assumptions made about the data. Each *p*-value listed under the heading "Prob > |t|" represents the significance of the probability test used to test whether the effect of the parameter is significantly different from zero.

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	25	8838.67455	353.54698	6.96	<.0001
Error	404	20515.02243	50.77976		
Corrected Total	429	29353.69698			

R-Square	Coeff Var	Root MSE	yield Mean
0.301109	37.36186	7.125992	19.07291

Base: year 2001

Parameter	Estimate	Standard Error	t Value	Pr > |t|
Intercept	14.94249061	1.38701699	10.77	<.0001
anospart	-0.80147640	0.62294599	-1.29	0.1990
eca	**4.10006867**	**1.59823940**	**2.57**	**0.0107**
d_var1	**2.35065758**	**1.09290087**	**2.15**	**0.0321**
d_var3	-2.75805363	1.56507497	-1.76	0.0788
d_var4	-1.16698497	1.44447656	-0.81	0.4196
d_var5	0.25182060	1.23438942	0.20	0.8385
d_var6	-3.84274257	1.21942689	-3.15	0.0017
d_var7	1.93931946	2.31810241	0.84	0.4033
d_com1	7.34248572	1.77122527	4.15	<.0001
d_com2	1.79689901	1.85504774	0.97	0.3333
d_com3	3.97629846	1.62134425	2.45	0.0146
d_com5	-2.13079146	1.60035077	-1.33	0.1838
d_com6	-0.83493031	1.79295386	-0.47	0.6417
d_com7	0.32563275	1.54214026	0.21	0.8329
d_com8	2.14111933	1.66048932	1.29	0.1980
d_com10	-7.90745752	3.69267806	-2.14	0.0328
d_com11	5.10521133	1.76802024	2.89	0.0041
d_com12	-5.06074139	3.61934026	-1.40	0.1628
d_com14	-2.26628926	4.69994457	-0.48	0.6299
d_com15	5.55409889	1.58963554	3.49	0.0005
d_com18	1.82930589	1.71292664	1.07	0.2862
d_year2	-2.02333222	1.71506287	-1.18	0.2388
d_year4	3.79638044	1.03063429	3.68	0.0003
d_EA2	2.46602409	2.79639852	0.88	0.3784
d_EA4	-2.97147997	1.59535919	-1.86	0.0632

Base: year 2000

Parameter	Estimate	Standard Error	**t Value**	**Pr > |t|**
Intercept	12.91915839	1.79508258	7.20	<.0001
anospart	-0.80147640	0.62294599	-1.29	0.1990
eca	**6.56609277**	**2.68297070**	**2.45**	**0.0148**
d_var1	**2.35065758**	**1.09290087**	**2.15**	**0.0321**
d_var3	-2.75805363	1.56507497	-1.76	0.0788
d_var4	-1.16698497	1.44447656	-0.81	0.4196
d_var5	0.25182060	1.23438942	0.20	0.8385
d_var6	-3.84274257	1.21942689	-3.15	0.0017
d_var7	1.93931946	2.31810241	0.84	0.4033
d_com1	7.34248572	1.77122527	4.15	<.0001
d_com2	1.79689901	1.85504774	0.97	0.3333
d_com3	3.97629846	1.62134425	2.45	0.0146
d_com5	-2.13079146	1.60035077	-1.33	0.1838
d_com6	-0.83493031	1.79295386	-0.47	0.6417
d_com7	0.32563275	1.54214026	0.21	0.8329
d_com8	2.14111933	1.66048932	1.29	0.1980
d_com10	-7.90745752	3.69267806	-2.14	0.0328
d_com11	5.10521133	1.76802024	2.89	0.0041
d_com12	-5.06074139	3.61934026	-1.40	0.1628
d_com14	-2.26628926	4.69994457	-0.48	0.6299
d_com15	5.55409889	1.58963554	3.49	0.0005
d_com18	1.82930589	1.71292664	1.07	0.2862
d_year3	2.02333222	1.71506287	1.18	0.2388
d_year4	5.81971266	1.71685325	3.39	0.0008
d_ea3	-2.46602409	2.79639852	-0.88	0.3784
d_ea4	-5.43750407	2.73928445	-1.99	0.0478

Appendix 6

Significance test of the difference between yields obtained by FFS participants/non-participants

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	Pr > F
yield	Folded F	200	228	1.10	0.4752

equality not refused >>>
t-test for equal variance

T-Tests (Ho= There is no difference in yields)

Variable	Method	Variances	DF	t Value	Pr > |t|
yield	Pooled	**Equal**	**428**	**-3.45**	**0.0006**
yield	Satterthwaite	Unequal	415	-3.44	0.0006

The null hypothesis 'There is no difference in yields' was rejected. Yields of FFS farmers were significantly higher than those of non-participating farmers (p<0.001).

Appendix 7

Performance of 'Amarilis' compared with the performance of all the other varieties (t test to assess whether the means of the two groups differ significantly)

Variable	variety	N	Mean	Mean	Mean	Std Dev	Std Dev	Std Dev	Std Err
yield	1	125	20.694	22.212	23.729	7.6247	8.5716	9.7893	0.7667
yield	2	305	16.907	17.786	18.666	7.2285	7.8024	8.4762	0.4468
yield	Diff (1-2)		2.7485	4.4252	6.102	7.5289	8.0329	8.6097	0.8531

T-Tests

Variable	Method	Variances	DF	t Value	Pr > |t|
yield	Pooled	Equal	428	5.19	<.0001

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	Pr > F
yield	Folded F	124	304	1.21	0.1994

Performance of 'Amarilis' compared with the performance of the other 3 most important varieties (t test to assess whether the means of the two groups differ significantly)

Variable	variety	N	Mean	Mean	Mean	Std Dev	Std Dev	Std Dev	Std Err
yield	1	125	20.694	22.212	23.729	7.6247	8.5716	9.7893	0.7667
yield	2	160	16.817	18.023	19.23	6.9626	7.7266	8.6803	0.6108
yield	Diff (1-2)		2.2833	4.1884	6.0935	7.4912	8.1077	8.8356	0.9678

T-Tests

Variable	Method	Variances	DF	t Value	Pr > |t|
yield	Pooled	Equal	283	4.33	<.0001

Equality of Variances

Variable	Method	Num DF	Den DF	F Value	Pr > F
yield	Folded F	124	159	1.23	0.2171

Appendix 8

Net present value (NPV) and internal rate of return (IRR) without benefits of variety 'Amarilis', but considering all conceptual costs.

Year	Costs/ year (US$)	Number of participants	Total area: participants (ha)[a]	Benefits due to education: participants (US$/ha)	Benefits due to 'Amarilis': participants (US$/ha)	Area: non-participants (ha)[a]	Total benefits of education FFS (US$)	Total benefits of 'Amarilis': non-participants (US$)[b]	Total benefits of 'Amarilis': participants (US$)[b]	**Net benefit (US$)**
1997	20,000	0	0	0.0	0.0		0.0	0.0	0.0	(20,000.00)
1998	8,800	115	23	0.0	0.0		0.0	0.0	0.0	(8,800.00)
1999	14,300	160	32	236.0	350.0		7552.0	0.0	1120.0	(6,748.00)
2000	22,000	345	69	236.0	350.0	10.0	16284.0	437.5	13282.5	(5,716.00)
2001	17,600	274	69	236.0	350.0	25.0	16284.0	s2187.5	8452.5	(1,316.00)
2002	15,000		69	227.7	337.8	50.0	15714.1	4221.9	8156.7	714.06
2003			69	219.8	325.9	50.0	15164.1	4074.1	7871.2	15,164.07
2004			69	212.1	314.5	50.0	14633.3	3931.5	7595.7	14,633.33
2005			69	204.7	303.5	50.0	14121.2	3793.9	7329.8	14,121.16
2006			69	197.5	292.9	50.0	13626.9	3661.1	7073.3	13,626.92
2007			69	190.6	282.6	50.0	13150.0	3533.0	6825.7	13,149.98
2008			69	183.9	272.7	50.0	12689.7	3409.3	6586.8	12,689.73
2009			69	177.5	263.2	50.0	12245.6	3290.0	6356.3	12,245.59
2010			69	171.3	254.0	50.0	11817.0	3174.9	6133.8	11,816.99
2011			69	165.3	245.1	50.0	11403.4	3063.7	5919.1	11,403.40
2012			69	159.5	236.5	50.0	11004.3	2956.5	5712.0	11,004.28
2013			69	153.9	228.2	50.0	10619.1	2853.0	5512.0	10,619.13
2014			69	148.5	220.3	50.0	10247.5	2753.2	5319.1	10,247.46
2015			69	143.3	212.5	50.0	9888.8	2656.8	5133.0	9,888.80
2016			69	138.3	205.1	50.0	9542.7	2563.8	4953.3	9,542.69
									NPV	**18,423.39**
									IRR	**0.15**

[a] Assuming 0.2 ha potato area per farmer.

[b] Considering only that part of the 0.2-ha area planted with 'Amarilis'.

Appendix 9

Net present value (NPV) and internal rate of return (IRR) without benefits of variety 'Amarilis', and without conceptual costs.

Year	Costs/ year (US$)	Number of participants	Total area: participants (ha)[a]	Benefits due to education: participants (US$/ha)	Benefits due to 'Amarilis': (US$/ha)	Area: non-participants (ha)[a]	Total benefits of education FFS (US$)	Total benefits of 'Amarilis': non-participants (US$)[b]	Total benefits of 'Amarilis': participants (US$)[b]	**Net benefit (US$)**
1998	8,800	115	23	0.0	0.0		0.0	0.0	0.0	(8,800.00)
1999	14,300	160	32	236.0	350.0		7552.0	0.0	1120.0	(6,748.00)
2000	22,000	345	69	236.0	350.0	10.0	16284.0	437.5	13282.5	(5,716.00)
2001	17,600	345	69	236.0	350.0	25.0	16284.0	2187.5	8452.5	(1,316.00)
2002	15,000		69	227.7	337.8	50.0	15714.1	4221.9	8156.7	714.06
2003			69	219.8	325.9	50.0	15164.1	4074.1	7871.2	15,164.07
2004			69	212.1	314.5	50.0	14633.3	3931.5	7595.7	14,633.33
2005			69	204.7	303.5	50.0	14121.2	3793.9	7329.8	14,121.16
2006			69	197.5	292.9	50.0	13626.9	3661.1	7073.3	13,626.92
2007			69	190.6	282.6	50.0	13150.0	3533.0	6825.7	13,149.98
2008			69	183.9	272.7	50.0	12689.7	3409.3	6586.8	12,689.73
2009			69	177.5	263.2	50.0	12245.6	3290.0	6356.3	12,245.59
2010			69	171.3	254.0	50.0	11817.0	3174.9	6133.8	11,816.99
2011			69	165.3	245.1	50.0	11403.4	3063.7	5919.1	11,403.40
2012			69	159.5	236.5	50.0	11004.3	2956.5	5712.0	11,004.28
2013			69	153.9	228.2	50.0	10619.1	2853.0	5512.0	10,619.13
2014			69	148.5	220.3	50.0	10247.5	2753.2	5319.1	10,247.46
2015			69	143.3	212.5	50.0	9888.8	2656.8	5133.0	9,888.80
2016			69	138.3	205.1	50.0	9542.7	2563.8	4953.3	9,542.69
									NPV	**40,265.73**
									IRR	**0.28**

[a] Assuming 0.2 ha potato area per farmer.

[b] Considering only that part of the 0.2-ha area planted with 'Amarilis'.

Appendix 10

Results of sensitivity analyses:
Calculation of net present value (NPV) and internal rate of return (IRR) for scenarios in which the average size of potato plots was 0.15 ha and 0.25 ha.

NB An IRR greater than 0.22 indicates a cost-effective/worthwhile project.

Plot size 0.15 ha

All costs included but only education benefits considered	
NPV	-3,837.45
IRR	0.09

Only education benefits and only operational costs considered	
NPV	9,541.92
IRR	0.14

All costs included, but benefits of introduction of new variety for participants and non-participants considered	
NPV	50,074.78
IRR	0.23

Plot size 0.25 ha

All costs included but only education benefits considered	
NPV	40,684.23
IRR	0.21

Only education benefits and only operational costs considered	
NPV	54,357.84
IRR	0.30

All costs included, but benefits of introduction of new variety for participants and non-participants considered	
NPV	118,303.87
IRR	0.39

NPV and IRR for cases in which FFSs are used only for the diffusion of a new variety

Average potato area/farm 0.25 ha	
NPV	20,685.17
IRR	0.17

Average potato area/farm 0.2 ha	
NPV	14,660.56
IRR	0.16

Average potato area/farm 0.15 ha	
NPV	-2,587.19
IRR	0.09

Appendix 11

Often the most important economic impact of agricultural research is felt by consumers. This is true when research enhances an agricultural staple that a lot of poor people depend on, and which was previously in short supply. By boosting supply, prices are likely to fall, and this can benefit poor consumers.

In Peru, potato is an important staple food, but supply is seldom insufficient to meet demand. This means that, if the project was replicated in many parts of the country, so elevating overall production, prices would fall. However, reductions in the price of potato are becoming less important for consumers in Peru. This is because potatoes are being replaced by rice and wheat, even in the diets of poor rural people.

Of course the importance of potato is not the same at all social/geographical levels. But, it is important for the three categories we are especially interested in:

- the rural poor in mountain areas who spend between 5% and 9% of their household income on potatoes,
- the urban poor in mountain areas who spend 6% of their household income on potatoes and
- the urban poor in Lima and in other coastal cities who spend 5% of their household income on potatoes

(FAO, 2002; Webb and Fernandez Baca, 2002).

As these data are averages, the rural poor in mountain areas can be assumed to consume slightly more potatoes and less rice and wheat products than the data suggest. However, a reduction of 5% in the price of potato (from its current level of US$87.50/t) means that the poor population (the three lower quintiles) would save less than US$1 per person per year.

Furthermore, at the current low price, demand for potato is no longer closely linked to price. Therefore, consumers will not buy much more when prices drop. Additional consumption of potatoes will be limited. So, the budgets of neither poor nor rich consumers would be affected significantly.

If a 5% price reduction occurred, the loss experienced by a small-scale potato farmer (with 0.2 ha land, who produces 17 t/ha), would be US$14.88 ($0.2 \times 17 \times 87.5 \times 0.05$).

Therefore, if Farmer Field School projects were ‘upscaled’ to such an extent that potato prices fell (by an assumed 5%), the implication for this economic evaluation, is that the US$14.88 would have to be discounted from the benefits of US$50-80 obtained through yield increases.