Chapter 13
Evaluating Dissemination and Impact of IPM: Lessons from Case Studies of Potato and Sweetpotato IPM in Peru and Other Latin American Countries

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Abstract Integrated Pest Management (IPM) programs have been implemented in Latin American for several decades. Examples in the case of Peru include the successful IPM programs for cotton, citrus, olives, sugar cane and potatoes. However, impact assessment of such programs has not been common. Most of the IPM programs, except the potato case, did not include formal impact assessments neither efforts to document lessons about program implementation and methods used. This paper presents a historical analysis of potato IPM implementation in Peru in which the International Potato Center took part. The analysis is complemented with IPM cases on potato and sweetpotato from other Latin American countries, which enabled the extraction of factors that influence implementation and impact of IPM. The analysis indicates that IPM to become a reality at field level needs the coexistence of sound technical knowledge and solutions, inter-institutional cooperation mechanisms, collective action of farming communities and an enabling political environment, which is not common in most Latin American countries.

Keywords IPM · impact · potatoes · sweetpotatoes · Peru

13.1 Introduction

Integrated Pest Management (IPM) programs have been implemented in Latin America for several decades. Examples in the case of Peru include the successful IPM programs for cotton, citrus, olives, sugar cane and potatoes (Palacios et al.,

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2003). The content of these programs was based on results of IPM research activities mainly conducted on the entomology and agronomy disciplines, which were disseminated to farmers through the public extension systems that existed until the 1980s. Although, publications describe successful implementation of IPM, there have not been specific studies for assessing the impact of this technology prior to the 1980s. It was in the 1980s that other disciplines such as anthropology, economics and extension sciences began to look at IPM from a different angle, particularly at the International Potato Center (CIP). Since the mid 1980s, different socioeconomic studies have been conducted to assess, for example, farmers perceptions about pest control, cost-benefit analysis of pest control methods, and more recently the impact of IPM, which focused mainly on the economic benefits of this technology, but later focusing on impacts on other aspects of the farmer livelihood systems, such as human, social, and natural capitals.

This paper aims at analyzing IPM implementation with a human dimension, by extracting lessons from the socioeconomic and impact oriented studies of IPM, taking Peru, and particularly the potato crop, as a case study, but also using examples of other crops in other Latin American countries.

13.2 Potato IPM in Peru and Examples from Other Latin American Countries

The evolution of pest control in Peru, taking the example of the potato crop, is described by Ortiz (2006), who identifies some clear stages in the historical evolution of pest control; for example, prior to 1532, during the Inca Empire, a well organized agricultural system existed and pest populations were regulated mainly by crop rotation using the “sectorial fallowing system” which consisted of rotating crops on a communal basis, meaning that all farmers in a community agreed to plant one single crop (i.e. potatoes) in a sector of the community, and then all moved to another sector, in which potatoes had a 7-year rotation period (Hastorf, 1993; Zimmerer, 1991). However, during the Colonial era, between 1532 and 1821, the whole agricultural system began to be disrupted; particularly rotational periods were reduced, which did not allow the fields in the high Andes to recover in terms of fertility and soil health. During the first century of the Republican era, between 1821 and 1930s, the disruption of the systems continued and potato pests increased. It was in the 1950s when pesticides were introduced to the potato systems, and their use has been growing ever since. As a response, potato IPM programs, particularly to control the Andean potato weevil (*Premnotrypes* spp.) and the potato tuber moths (*Symmetrischema tangolias* and *Phthorimaea operculella*) began to be tested in farmer fields in the late 1980s, and these programs have been growing through inter-institutional collaboration. Potato IPM was promoted by the International Potato Center (CIP) and the National Agricultural Research Institute (INIA) of Peru (CIP, 1995). CIP also launched sweetpotato IPM programs in Central America. Alvarez et al. (1996) described the impact of IPM for controlling the sweetpotato weevil (*Cylas formicarius*) in Dominican Republic, which was based on the use of sex pheromones as attractants and the appropriate use of pesticides. Maza et al. (2000) and Cisneros and Alcázar (2001) described another interesting case of sweetpotato IPM in Cuba, where the program was based on a combination of pheromone use, biological control with the fungus *Beauveria bassiana* and the predatory ants (*Pheidole megacephala* and *Tetramorium guineense*) as well as different cultural practices.

Potato IPM programs were also implemented in Bolivia and Ecuador through collaborative agreements between CIP and the National Agricultural Research Institute (INIAP) in Ecuador and with the Potato Research Program (PROINPA) in Bolivia. In both cases, the national research institutes adapted IPM practices to control the Andean potato weevil and the potato tuber moths developed by CIP in Peru to their local conditions.

Potato IPM has not been the first example of using this technology in the Peruvian agricultural systems. Palacios et al. (2003) presented a comprehensive description of the IPM evolution in Peru indicating that it was in the 1937 when a program of classic biological control in olives was implemented to control the black scale (*Saissetia oleae*), which lasted about 17 years. Valdiviezo (1998) even reported earlier attempts to introduce beneficial insects in 1904 to Peru. Later, in the 1940s, a successful biocontrol program for the sugar cane borer (*Diatraea saccharalis*) was implemented. The introduction of an exotic parasitoid failed but inundative releases of *Paratheresia claripalpis* reduced damage by 83% due to high parasitism (88%). This program was significantly impaired because of new policies during the Agrarian Reform in the 1970s. In the 1950s, and in response to problems caused by the indiscriminate use of pesticides in cotton, which according to Daily (1997) reached up to 21 sprays per season, a private farmer organization (Farmers' Association of the Cañete Valley, located in the Peruvian Central Coast) organized an IPM program to reduce the use of highly toxic pesticides through the implementation of improved cultural practices, pheromone, biological control applying inundative releases of the egg parasitoid *Trichogrammatoidae bactrae* to control the Indian pink bollworm (*Pectinophora gossypiella*), one of the major cotton pests and others. The number of sprays dropped to about 2 per season. The control measures have continued since then with some variations, but in general following the same principles. The applied control measures against the Indian pink bollworm reduced by 70% the use of pesticides (Castro et al., 1997), or when focusing on organic production reduced production costs by 50% (Van Elzakker, 1999). There was also the case of IPM for citrus, which was implemented in the 1960s, basically focusing on the successful introduction of biological control agents.

As indicated, biological control agents to control insect pests in several crops, particularly in citrus, cotton, and sugar cane, were introduced to Peru since 1904. Valdiviezo (1998) lists the introduction of a total of 98 beneficial species during the period of 1904–1998. Studies indicated that 29 species have established, and 13 species controlled completely 11 pests. The economic benefit of 10 beneficial species for controlling 9 pests was calculated to amount to US$ 39 millions annually for pesticide savings. Some examples of successful introductions include the species *Aphelinus mali* to control aphids in apple (*Eriosoma lanigerum*), *Rodolia cardinals* to control cottony cushion scale *Icerya purchasi* in fruit trees, wasp species (*Scutellista cyanea, Metaphycus lounsburyi* and *Lecaniobius utilis*) that were efficient to control black scale *Saissetia oleae* in olive trees, and wasps of the genus *Trichogramma* to control the sugar cane borer *Diatraea sacharalis*.

The common feature of these IPM programs was that they were implemented in relatively high value industrial or export crops. In the early 1990s, IPM for potato pest management was introduced to Andean communities through inter-institutional cooperation. Fano et al. (1996) describe the collaborative activities between the CIP and extension organizations as an alternative way to facilitate farmers' access to information and technologies. Since 1992, CIP has established several contacts with NGOs in order to disseminate its research results to resource-poor farmers in the Peruvian Andes. For example, a collaborative project was implemented between CARE-Peru and CIP in order to train farmers in IPM (Chiri et al., 1996; Ortiz, 1997). However, this effort gave priority to the technical aspects of IPM, and paid little attention to the use of participatory methods for training farmers.

Between 1995 and 2000, an inter-institutional potato IPM program took place with the participation of CARE-Peru, Ministry of Agriculture, CIP and the financial support of the United States Agency for International Development (USAID). This program aimed at the dissemination of potato IPM to Andean communities in large scale, taking advantage of the decentralized extension network of the National Program for Soil Conservation (PRONAMACHS) from the Ministry. Several courses, manuals and farmer training activities were conducted, focusing on a conventional extension approach. However, there is no evidence about the number of farmers that were reached through this program.

In 1998, CIP began to implement integrated disease management against potato late blight (*Phytophthora infestans*) using participatory research and training methods, such as the farmer field school (FFS) approach (Nelson et al., 2001; Ortiz et al., 2004). This experience showed that working with knowledge-intensive technologies such as IPM required methods that facilitated farmers' learning process. In 1997, CARE-Peru and CIP initiated the testing and dissemination of participatory research and training approaches based on the FFS experience (Nelson et al., 2001), which put emphasis on adapting a participatory method to help farmers understanding complex biophysical principles involved in pest control, moving beyond technology or information transfer to promoting hands-on learning for improving decision-making. FFS was shown to be an effective way to enhance information exchange, learning, and the adoption of IPM. Farmers learned complex concepts more efficiently than with alternative extension approaches, and new knowledge was associated with increase in productivity (Godtland et al., 2004; Ortiz et al., 2004).

In recent years, institutions such as NGOs have been promoting an approach called ecological pest management (EPM), which derives from IPM, and emphasizes the use of botanical insecticides, beneficial insects and entomopathogens in crops such as potato, beans, onions, cotton and vegetables (Arning and Lizárraga, 1999). This approach has been promoted actively by the "Red de Acción en Aternativas al uso de Agroquímicos – Raaa" (Action Network for Alternatives to the Use of Pesticides) through training, research, promotion and the formation of micro enterprises for the production and marketing of IPM-related inputs. A combination of different means for information delivery, such as courses, seminars, demonstration plots, publications and radio programs was used reaching about 6,000 beneficiaries between 1991 and 1995 (Hollands and Lizárraga, 1998). However, there is no evidence in the literature about the impact of these programs.

Chavez-Tafur et al. (2003) indicated that there has been a movement towards ecological organic agriculture in Peru, resulting in the formation of a national association of ecological producers, which included farmer organizations and institutions, providing certifications for this type of agriculture. This factor has resulted in a renewed interest in IPM, particularly when associated to crops for specific organic markets.

More recently, FAO coordinated an inter-institutional IPM program using the FFS approach building upon CIP and CARE previous experience (Nelson et al., 2001; Ortiz et al., 2004). This project was implemented between 2001 and 2003 with the participation of governmental institutions such as the National Institute of Agricultural Research (INIA), the National Agricultural Sanitation Service (SENASA), La Molina University, and several NGOs. In an initial phase, the project included potato IPM in the Peruvian Highlands, and cotton IPM in the coastal region. Later, other crops such as coffee, citrus, peanuts, maize, bean, banana, aromatic herbs, vegetables, and also some cases of integrated management of livestock pests were included. A total of 200 FFS were implemented in 2002 and 2003 generating benefits for farmers in terms of accessing information and knowledge about pest biology and ecology and control methods. In addition, farmers learned to experiment with pest control methods on their farms. Some lessons learned indicate that IPM implementation is not only about the technical content, but also the appropriate way of delivering information. This requires adequate participatory research and training methods that supports farmer understanding of complex concepts related to pest control (Groeneweg et al., 2004).

The participation of farmers in adapting IPM has been essential because of the high variability of agro-ecosystems existing in the Peruvian territory, particularly in the Andean region. This is particularly important when dealing with pests, which are highly influenced by the environment, such as potato late blight that is influenced by relative humidity and temperature. Therefore, technologies that work for a farmer in one location may be different for other farmers located at higher or lower altitude, and that is why farmer opinion and contribution with their local knowledge about their conditions is essential to adapt IPM.

13.3 Potato and Sweetpotato IPM Implementation and Dissemination. Cases from Latin America

13.3.1 Technology Transfer Phase: The Pilot Area Approach

CIP in collaboration with INIA initiated the implementation of potato IPM programs in the late 1980s. The approach used by researchers and extension workers in the early 1990s was called IPM pilot units, which were implemented at community level (Cisneros, 1999). The first pilot unit was located in the Peruvian Southern highlands, in a community called Chincheros. The idea was to evaluate the effect of different control practices against the Andean potato weevil. About 60 farmers were involved during 3 years and the records indicated a decrease of the weevil damage to harvested tubers from originally 31% to 11% (Ortiz et al., 1996). There were other pilot units within Peru in the Central and Northern highlands, where farmers had access to information directly from researchers (Ortiz, 1997). Other cases of pilot units were built up in Ecuador, Bolivia, Dominican Republic and Cuba. The main characteristics of the pilot units were that an agronomist trained on pest control was permanently presented in the communities, who was in charge of assessing farmer practices, IPM training and gathering farmers' opinions about the new IPM technologies. Researchers frequently visited pilot units to conduct pest-related research. Extension workers received IPM training too, but were not trained on how to teach IPM to farmers. As a result, extension workers were very active trying to develop training approaches using their own creativity (Ortiz, 1997, 2006), which included visits to fields to see over wintering places for insects, visual aids to explain insect life cycles, dramas and games to explain insect behavior, which took considerable time. The experience demonstrated that prioritizing the technical IPM component was not sufficient. The technology required appropriate methods to facilitate learning and dissemination, so that farmers could acquire timely information and knowledge; finally these were essential elements for the adoption of IPM. At that time a clear demand for IPM-related training methods began to be expressed among participating institutions (Ortiz et al., 1997; Ortiz, 2001).

Impact assessment of the pilot unit approach was conducted using an economic approach consisting on estimating the net benefit of IPM at field level, taking samples of farmers fields and assessing insect damage at harvest time, the rate of adoption and comparing costs and benefits of the program using the internal rate of return and the net present value estimates. At that time, economic impact was the focus of the analysis and results showed that farmers could achieve an average benefit of about US$ 100/ha because of the adoption of IPM, which compared favorably with other investments in agricultural research and development. Although the pilot unit approach was replicated in several places of Peru, for example, with the support of the Inter-American Development Bank (BID), a potato IPM program was implemented to control potato insect pests in the Central Highlands and also Central Coast in Peru, basically to control the Andean potato weevil and the leaf miner fly

Liriomyza huidobrensis, respectively. The program was successful in bringing scientific information to farmers about innovative pest control methods, using mostly conventional extension methods such as field days, demonstration plots and individual or group training.

In general terms, there is not an up-dated assessment of the level of adoption that potato IPM reached. The review of files indicates that information about potato IPM reached about 5% of Peruvian potato growers, but there has not been a formal assessment so there is no evidence to estimate real adoption. Because of the lack of a functional extension service and difficulties for farmer-to-farmer dissemination of complex technologies such as IPM, there is no strong reason to believe that the adoption moved beyond that point. An additional aspect in the assessment was related to the number of IPM practices disseminated, and the difficulty to estimate how many were needed to consider the technology adopted. Hence, the question at that time was if IPM adoption consisted in the adoption of a number of pest control practices, or of the decision-making process to select appropriate pest control practices. The emphasis was on the former.

13.3.2 Participatory Research and Training for IPM: The FFS Experience

The lessons learned during the pilot unit phase have led to start looking at other experiences related to IPM training and implementation. Practitioners were interested in methodological innovations that could facilitate farmers' uptake of IPM beyond the pilot units. The idea of the FFS approach was introduced to Peru by a CIP scientist who previously gathered experiences in Asia on rice FFS (Nelson et al., 2001). This method was the best bet for teaching IPM at that time, and a process of adaptation began through a collaborative project between CIP and the NGO CARE-Peru. Between 1998 and 2001, the FFS method was adapted to potato related IPM, giving emphasis to late blight control. Although, the idea was to develop a method that could facilitate farmers' understanding of complex concepts on the biology, reproduction and dissemination of the microorganism that causes late blight, the experience soon revealed that there was also the need to evaluate the efficacy of control technologies in specific locations of different agro-ecologies. Late blight occurrence and incidence depends on the susceptibility of the cultivars, the climate (humidity, rain and temperature) and on farmers' management practices. Therefore, the FFS that were at the beginning initiated as a learning method for farmers were used for participatory research, being called participatory research through FFS (PR-FFS). This allowed farmers to assess technologies and scientists to collect information about the performance of the technologies in a range of socioeconomic and agro-ecological situations. The combination of learning and technology assessment seemed to be the right approach to tackle a complex problem such as late blight. In this way, new resistant cultivars and clones were introduced and jointly evaluated with farmers and, at the same time, farmers learned about how to control this disease. Although, this project was initiated focusing on late blight, farmers demanded also information on control methods for other pests, such as the Andean potato weevil and potato tuber moths, resulting in a more integral potato pest control program. Additionally, potato agronomic cultivation practices were included[1].

The adapted version of the FFS, which combined participatory research and training, generated impact in terms of changes in farmers' knowledge about potato management, influencing positively the productivity of potatoes. Godtland et al. (2004) reported that knowledge increase significantly because of the participation in FFS and that the input-output rate for potato could be increased by 32% as a result of additional knowledge. In addition, Zuger (2004) indicated that additional knowledge gained through FFS and the introduction of resistant cultivars generated productivity gains of US$ 236/ha and US$ 350/ha respectively, which showed the profitability of investing in training combined with participatory research. However, the amount of additional income from potato depended on the size of the potato plots, which tended to be less than 0.5 ha, which suggested that the impact of IPM, or of any other technology, should be assessed in terms of the contribution to the total income of the farm to see the real benefit for farmers.

The adaptation of the FFS method by CIP and CARE initiated the scaling-out of the methodology to other contexts and crops. In Ecuador and Bolivia, the national agricultural research institutions, the Agrarian National Research Institute (INIAP) and the private research foundation for potato and Andean crops (PROINPA) respectively, also adapted the approach to their local conditions. Groeneweg et al. (2004) indicated that with the support of FAO the method was replicated in cotton, tomato, maize, coffee, vegetables as well as in potato. CARE-Peru adapted the method to work on pest control and market aspects of native fruit trees. Anecdotic evidence indicates that at least ten other institutions have tried the FFS method, and that there is continued interest to adapt it to new problems and topics, for example, for pest control on livestock.

The FFS experience showed the need to provide training to farmers using appropriate methods, and to introduce suitable technologies that could complement farmers' knowledge to make appropriate decisions. However, implementing FFS requires skilled staff, organizational response on the part of communities and farmers, and adequate financial support to run the method properly, which still remains a challenge. The FFS method was introduced to Peru in 1998 and there is evidence that it has been replicated in more than 10 institutions. However, the spread and reach of this method has not been studied yet.

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[1] Alternatives to control the Andean potato weevil include elimination of volunteer plants, nocturnal hand-picking of adult weevils, turn-over of soil in infestation sources, use of sheets to pile potatoes during harvesting and sorting, harvest on time, use of chickens as larva predators, use of diffused light stores, trenches around stores or fields, biological control agents, and vegetative or chemical barriers (Alcázar et al., 1994).

13.4 Retrospects and Prospects of IPM: Some Lessons from Impact Assessment of Potato and Sweetpotato IPM

In the last 15 years, CIP has been engaged in the promotion of potato and sweetpotato IPM in some Latin American countries. For potato, IPM programs were implemented in Peru and subsequently in Bolivia, Ecuador, Colombia and Dominican Republic. For sweetpotato, the work was focused in Dominican Republic and Cuba. These IPM cases allow for a comparative analysis by describing the main characteristics of factors that enabled or hindered the adoption of technologies and finally the impact achieved of the different IPM interventions (Table 13.1).

Formal assessments were carried out during and immediately after the programs ended, using as indicators the rate of adoption, the net benefit of IPM adoption expressed in US$ per ha, and the cost of IPM development and implementation in each program, but no formal follow-ups of adoption were performed further, only anecdotic information could be used for this analysis.

In terms of economic impact, in all cases the internal rates of return (IRR) to investment for IPM development and dissemination were between 27% and 49% and compared very favorable with other types of investments in agricultural research. The IPM adoption at the pilot sites was encouraging, and the achieved additional net benefits on potato or sweetpotato ranged from US$ 100 and US$ 536 per ha. Very exceptional in the case of Cuba, the adoption for managing the sweetpotato weevil (*Cylas formicarius*) occurred beyond the pilot sites and reached about 50% of the total sweetpotato production area. There is no evidence that something similar happened in potato IPM in the Andean region. In all IPM programs, there was the need of a substantial investment for the introduction, adaptation, development and dissemination of IPM practices. Compared to classical biocontrol programs, however, the profitability of these IPM projects is relatively low. Valdiviezo (1998) reports that the naturalization of 10 exotic beneficial insects to control pests in different crops in Peru has generated annual pesticide savings of about US$ 39 million. The difference is that classic biocontrol has been introduced to relatively high value crops in most cases, which is different to the potato that still tends to be a food security crop.

The lack of follow-up studies in the IPM cases presented before indicates that there has been limited learning from the cases in terms of successes and failures. When learning and documentation do not happen, new IPM projects do not built on the lessons learned but tend to duplicate efforts or make similar mistakes than in the past.

The comparative analysis suggests that the main enabling factor for the success of a program and IPM adoption was the strong collaboration between research and development-oriented institutions, and in the case of Dominican Republic, the participation of the private sector, which facilitated the participatory adaptation of IPM strategies according to each location. Synergies can be clearly achieved when an international agricultural research center, national agricultural research institutes, non-governmental organizations, private sector and farming

Table 13.1 Main features of potato and sweetpotato IPM programs in Peru, Ecuador, Dominican Republic and Cuba

IPM program Feature	APW Peru (1990–1996)[1]	LB Peru (1998–2005)[2]	APW Ecuador (1994–1998)[3]	APW Bolivia (1995–1998)[4]	SPW, Dominican Republic (1992–1994)[5]	SPW, Cuba (1994–1998)[6]
Benefit/ha and internal rate of return (IRR)	US$ 100/ha IRR: 30%	US$ 536/ha IRR: 31%	US$ 270/ha IRR: 33%	US$ 101.8 IRR: 18%	US$ 100/ha IRR: 27%	US$ 126/ha IRR: 49%
Intervention method	Pilot sites (conventional group training)	FFS (hands-on learning activities).	Pilot sites (conventional group training)	Pilot site (conventional group training).	Pilot site (conventional group training).	Pilot sites as part of government interventions.
Status of adoption	Limited beyond the pilot sites.	Limited beyond the FFS intervention area.	Limited beyond the pilot sites.	Unknown	Limited beyond the pilot sites.	Exceeded expectations, went beyond pilot sites.
Enabling factors	Collaborative project between CARE and CIP.	Collaborative project. Participatory method facilitated farmers' learning and adoption.	Collaborative project between CIP and INIAP enabled local adaptation of IPM.	Collaborative project between PROINPA and CIP enabled the adaptation of IPM to local conditions	Collaborative effort facilitated the work. Support of the private sector (JAD).	Collaborative project. Political commitment, functional extension service and collective action. No competition from agrochemical companies

Table 13.1 (continued)

IPM program Feature	APW Peru (1990–1996)[1]	LB Peru (1998–2005)[2]	APW Ecuador (1994–1998)[3]	APW Bolivia (1995–1998)[4]	SPW, Dominican Republic (1992–1994)[5]	SPW, Cuba (1994–1998)[6]
Hindering factors	Lack of functional extension service for scaling-out. Strong competition of agrochemical companies.	Lack of functional extension service for scaling-out. Strong competition of agrochemical companies.	Limited extension services for scaling-out. Strong competition of agrochemical companies.	Inexistence of a government extension service. Strong competition of agrochemical companies.	Limited availability of pheromones after project cycle, and limited support of the government for scaling-up.	Limited availability of pheromones after project cycle.
Main lessons	Working at community level is essential for developing IPM.	IPM requires participatory methods to facilitate learning and adoption, but that increases the cost.	Adaptation of IPM principles developed in other context is essential.	IPM options do not reduce the need for insecticides. The pilot site approach is too specific for IPM and farmers face a number of problems.	Availability of IPM inputs needs to be taken into consideration from the beginning.	Commitment of policy-makers, and collective action facilitated implementation.

Key: APW: Andean potato weevil (*Premnotrypes spp.*), SPW: Sweetpotato weevil (*Cylas formicarius*), LB: late blight (*Phytophthora infestans*).
[1]Ortiz et al. (1996), [2] Zuger 2004, [3] Barrera and Crissman (1999), [4] Esprella et al. (2001), [5] Alvarez et al. (1996), [6] Maza et al. (2000).

communities work together towards common objectives. In Peru, the partnership between CIP and CARE-Peru was initiated with an IPM program in 1993 and has lasted 15 years. Initially working with the pilot site approach and the collaborative effort resulted in the adaptation of FFS as a participatory research and training method for IPM (Ortiz et al., 2008a). A similar partnership has happened between PROINPA foundation and CIP in Bolivia. In Ecuador, CIP and the National Agricultural Research Institute (INIAP) collaborated with local organizations and farming communities for the adaptation of IPM, first through the pilot site approach and later through the FFS method. In Dominican Republic, there was the participation of the "Junta Agroempresarial Dominicana – JAD" (Agro-entrepreneurial Dominican Association). In Cuba, favorable for the program was the political (by law) and institutional commitment towards IPM development and implementation, and had its main cause in the limited access of Cuban agricultural sector to agro-chemicals after the end of the Soviet Union. As a result, the government sector (research and extension) and the state cooperatives were organized to facilitate IPM implementation. Cooperatives built and maintained units for the mass production of the entomopathogen (*Beauveria bassiana*) to control the sweetpotato weevil. The coexistence of political will, institutional support and collective action made the large-scale implementation of the IPM program possible and a full success. In contrast, in all other countries, a lack of political support for IPM implementation was one of the main hindering factors for a large scale adoption. The weak government extension services prevalent in most countries prevented the scaling-out of the IPM experiences beyond the pilot sites although some special projects that tried to promote the spread of the technology. Köli (2003) concluded that adoption of IPM for the Andean potato weevil depends on a relatively well-organized extension or education service with a stable presence in the communities, which is in line with the experiences made at IPM pilot units or FFS. Further this author pointed out that the coordination of a large number of GO and NGO would be needed for scaling-out IPM experiences; the great variability of agro-ecological and economic conditions, farmer perceptions including availability of time and personal attitudes calls for a better "IPM product differentiation", meaning fine tuning IPM strategies according to different types of farmers. One additional hindering factor has been the strong competition of agrochemical companies, which have aggressive selling strategies and well-established selling networks, so that farmers have access to pesticides with relative facility, compared to IPM-related advice or inputs.

Limited availability of some IPM inputs has turned out being often another important factor for IPM adoption. In the Dominican Republic and Cuba, the availability of pheromones was reduced substantially after the project cycle. Local production could not build up and the importation from the Netherlands was too costly; recently it was shown that pheromones produced in China are used. In IPM leaflets and brochures produced by national programs it can be often observed that IPM items like pheromones are mentioned but which are not available on local markets. In Peru, there were some government and non-governmental organizations that attempted to produce biological control agents such as the fungus *Beauveria bassiana* to control the Andean potato weevil and the potato tuber moth granulovirus (*Po*GV) to control potato tuber moths, but results were not encouraging, and the private sector has not been part of the efforts so far.

Collective action was clearly present in Cuba but not in the other countries, where farmer organizations are weak and no mechanism for promoting collective action exists. According to the experiences and the lessons learned at the pilot units and FFS, the commitment of farmer organization to IPM is utmost important; where it does not exist, the chances of adoption are very low.

IPM is clearly a type of technology that depends on an enabling innovation system, meaning the existence of relatively strong research and development organizations and also strong farmer organizations, which can make collective action for IPM a reality. The technology also requires inter-organizational coordinated efforts, which are not easy to initiate or to sustain over time (Ortiz et al. 2008b)

13.5 Concluding Remarks: Some Lessons for the Future

IPM to become a reality at field level needs the coexistence of sound technical knowledge and solutions, inter-institutional cooperation mechanisms, collective action of farming communities and an enabling political environment. The relatively appropriate combination of these factors existed for the successful implementation of an IPM program only in Cuba. The lack of some or all of these factors has negatively influenced the IPM adoption in the other examples presented in this paper.

Unless the availability of IPM-related inputs (i.e. pheromones) is ensured, also after the end of the projects, these IPM inputs should not be promoted as part of an IPM program, because it creates expectations that cannot be fulfilled. Otherwise the reliability of the project and the IPM technology will be negatively affected and the IPM adoption could drop sharply after the project.

Working at the community level is essential for IPM development and implementation, which was the main contribution of the pilot unit approach. Prior, IPM practices were tested in individual plots only, where no real understanding could be achieved for all those factors which might influence IPM implementation. IPM assessment at community level with the participation of many farmers and institutional actors is more meaningful and accurate, because it involves different points of view. Appropriate participatory research and training methods are important to facilitate the understanding of IPM by farmers, which was the main contribution of FFS to the pilot unit approach.

The economic impact of IPM at pilot sites of FFS communities has been encouraging and is an important parameter to take into consideration. However, also impact on human capital like changes in stakeholder knowledge and skills is important, which could last even beyond the IPM program or the crop in hand. Impact in social capital can also be achieved when working with IPM programs, which requires inter-institutional and collective action. Again, strengthened social capital would have benefits beyond the specific IPM programs. However, most of the IPM programs analyzed in the paper did not assess the importance and changes of social capital and its influence on IPM scaling-up and implementation. Some indicators of impact at the level of human capital include, for example, proportion of farmers recognizing stages of pest life cycles, infestation sources, and ways the insect reaches fields or stores. Also, proportion of farmers who are able to explain how, why and when IPM practices should be used. Examples of indicators of changes in social capital include the existence of farmer organizations, the formalization of them, number of sources of information and access to credit related to pest control.

Farmers' characteristics are changing rapidly in response to market development, globalization, urbanization and threats to human health. In general farmers are diversifying their sources of income, meaning that they are engaged in more and different on and off-farm activities. IPM strategies and program need to take those new conditions into consideration by developing strategies and products more target oriented. Product differentiation is a well-known concept in the private sector, which should also be considered in public IPM research and intervention.

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