Session X

Participatory technology development information and innovation systems

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Technological and organizational innovation: Evolving paradigms and challenges to promote root and tuber crops for poverty alleviation

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Abstract

In the last fifty years, theoretical and practical approaches to promoting agricultural innovations have been evolving. Initial theories of innovations diffusion lead to a linear, top-down approach of technology transfer under the assumption that technological innovations only came from research. This approach has influenced for several decades the way in which agricultural research and development organizations have operated, for example, during the green revolution and the use of the training and visit (T&V) system. The technology transfer approach fit in to a relatively stable institutional environment with the large government-centered research and extension services that existed at that time. However, the external environment started to change in the 1970s and 1980s. Participatory research was proposed to enhance technological design and adoption. Economic structural adjustment accelerated changes causing a dramatic decrease in governmental agricultural research and extension services. Simultaneously a number of new stakeholders (NGOs, private sector, farmer organizations, local governments, etc.) started to contribute to agricultural innovations in the 1990s and 2000s. As the changes occurred, scholars started to propose new theories aiming at explaining how multiple stakeholders interact, exchange information, generate knowledge and develop innovations for solving problems. Approaches such as the agricultural knowledge and information system (AKIS), learning selection, learning to innovate and innovation systems have been proposed and, despite some differences, there is consensus in recent literature that for promoting agricultural development, the combination of technological, methodological and (inter) organizational innovation is required. Organizations working with root and tuber crops need to pay attention to recent innovation approaches if they want to unleash the potential of these crops and alleviate poverty. There are challenges regarding developing the practical methods needed to use the innovation systems approach, and how to promote inter-organizational learning. Research organizations in partnership with public and private stakeholders have a renewed role to play in helping them to adjust to climate change, globalization, and emerging food and financial crisis.

Keywords: Technological innovation, organizational innovation, root and tuber crops.

Introduction

Promoting technological change in agriculture has been a permanent preoccupation of public and private organizations since agriculture first began to use scientific results to improve productivity and efficiency in the sixteenth and seventeenth centuries. Interestingly, potatoes were related to the beginning of formal agricultural extension. The first formal "extension" system promoted by a government was implemented in Ireland after the potato famine in 1847. The idea was to deploy "itinerant lecturers" or "instructors" in charge of providing advice to farmers to help them to reduce the consequences of the famine. Although in North America there were also "itinerant teachers" in charge of providing agricultural advice, this effort was mainly promoted by the agricultural societies (Swanson and Claar, 1984). In developing countries such as Peru, there is also evidence that agricultural societies (farmer organizations) influenced the creation of agricultural universities and other forms of technological innovation in the early twentieth century. Previous to that date, farmers (basically land-lords who owned haciendas) were in charge of bringing agricultural innovations to their farms. During colonial times in Peru, there is no evidence of formal government efforts to promote agriculture, which was radically different from the Pre-Columbian era where the Inca Empire was built based on agriculture, and there were formal and informal ways of disseminating agricultural information (Ortiz, 2006).

Root and tuber crops are essential components of small farmers' production and food systems in developing countries. The area cultivated with these crops, particularly with potatoes, has been increasing steadily in the last decade because of their contribution to food security and income generation (Scott et al., 2000). However, there are still other roots and tubers with great potential which have not been utilized sufficiently.

In several developing countries, formal extension services started in the mid twentieth century, and in the last fifty years, theoretical and practical approaches to promoting technological change in agriculture have been evolving in response to changes in the external environment (agroecosystems, institutions, policies, and markets). The objective of this paper is to explain how theoretical approaches to promoting agricultural innovation have changed and discuss the implications of those changes for promoting root and tuber crops in order to alleviate poverty

Agricultural innovation, some definitions

The brief history of agricultural extension explained above serves as an introduction to the concept of agricultural innovation. The term innovation refers to the understanding and use of a new idea, practice or method, which replaces something that an individual or organization has been using so far. For this paper the new ideas, practices or methods are related to agriculture. Innovation can be conceptualized as a "product" or "end result" by some authors such as Rogers (1962, 1995), while other authors conceptualize innovation as a process; for example, the process of generating new knowledge and applying it in a productive way (Hall et al., 2003, 2004), or as new ways of coordination and adjustment among people, technologies or natural phenomena (Leeuwis, 2004). Although, this discussion would seem to be theoretical, it has had practical implications. For example, in the mid twentieth century, innovation was conceptualized as a product (basically using the diffusion of innovations theory proposed by Rogers, 1962, 1995, see below) and approaches related to linear, top-down, technology transfer were used at field level. In more recent years, innovation has been conceptualized as a process, influencing the use of new approaches such as agricultural knowledge and information systems (Rölings 1990; Engels, 1997), learning selection or learning to innovate (Douthwaite, 2002, 2009), and innovation systems (Hall, et al., 2003, 2004; Hall, 2009). The way in which these theoretical concepts have evolved and its practical implications are described below.

Evolving theories of agricultural innovation and implications for root and tuber crops

Innovation theories have influenced the way institutions have designed and implemented agriculture-related interventions. In turn the organizational and political context has also influenced theoretical and methodological approaches to innovation. Over the years, the number of stakeholders related to agriculture has increased and their roles diversified, which has had implications for the type of theories needed to interpret reality. In the following sections, the main theories related to innovation and the contexts to which they relate are discussed in terms of their implications for agricultural research and development.

The stage of relatively stable contexts, few stakeholders and linear approaches

The initial theories of "diffusion of innovations" launched in the mid twentieth century, (Rogers, 1962, 1995) were developed when the context related to agriculture was relatively simple and stable. There was supposed to be a source of technologies or innovations (usually research organizations), a way of disseminating technologies (usually the extension services), and the users of those technologies (farmers). These original ideas lead to linear, top-down approaches to technology transfer under the assumption that the main drivers of innovation were the originators of it, meaning the research organizations. This approach has influenced for several decades - and still does influence - the way in which agricultural research and development organizations operate.

The green revolution was one of the practical consequences of such an approach. The idea at that time was that international agricultural research centers were going to develop innovations, which were going to be passed on to national agricultural research and extension organizations and then to farmers. The approach worked relatively well in some locations such as in Asia, but it did not work well in other parts of the world such as Sub-Saharan Africa (Pachico et al., 2000). The extension approach called the training and visit (T&V) system was also based on the diffusion of innovation theory and was promoted by donor agencies since the 1970s. This approach implied that there was a source of technologies (researchers) who passed messages to extension workers, who in turn passed the technologies on to contact farmers. These farmers were then in charge of sharing the messages with about ten farmers each who again were supposed to pass the message to other farmers (exactly fitting in with the diffusion of innovations theory). Despite the fact that the model was promoted in several countries involving large investments, some evaluations indicate that the results were not promising (Antholt, 1994).

The diffusion of innovation (technology transfer) approaches fit in to a relatively stable institutional environment with large government-centered research and extension services, prevailing in most developing countries, aimed at reaching as many farmers as possible. Because of this, governments and donors prioritized important staple cereal crops such as rice, wheat and maize, leaving root and tuber crops relatively unattended; although some important roots and tubers such as cassava and potatoes were also included in the agenda. Therefore, at that time the theoretical approach to innovation fit into the context and vice versa. However, this situation started to change in the last three decades of the twentieth century.

The stage of changing contexts, new stakeholders and multi linear approaches

The relatively stable environment for agricultural research and development prevalent in several developing countries between the 1940s and 1960s started to change in the 1970s and 1980s; at the same time new approaches such as participatory research emerged. Some authors indicated that innovation could come from sources other than researchers, particularly from farmers who used their indigenous or local knowledge for that purpose. Consequently the "farmer first" and other participatory approaches started to be developed (Chambers et al., 1989). The changes in the external environment were accelerated by the implementation of economic structural adjustment in several developing countries, with the consequent dramatic decrease in governmental agricultural research and extension services. Simultaneously a number of new stakeholders (NGOs, private sector, farmer organizations, local governments, etc.) started to contribute and, in some cases, take the lead in promoting agricultural innovations during the 1980s and 1990s (Bebington et al., 1993; Umali and Schwartz, 1994; Ameur, 1994).

The appearance of new stakeholders involved in agricultural innovation, or the realization of their importance among donors and scholars, highlighted the need to improve linkage mechanisms for sharing information and knowledge (Kaimowitz et al., 1990). The new context and the need for these better linkage mechanisms lead to he agricultural knowledge and information system (AKIS) approach (Röling, 1990; Engel, 1997). This approach proposes that innovation is the result of networking among individuals, groups and organizations for the generation and use of information and knowledge to solve problems. This was a pioneering approach for dealing with the increasing number of new stakeholders related to agriculture. At the same time, the participatory research movement continued to evolve, and stakeholders started to be more interested in root and tuber crops. For example, sweetpotato and Andean root and tuber crops were added to the research agenda of the International Potato Center during the 1980s.

The stage of increasing complexity, diversity of stakeholders and innovation systems

In the 1990s, the diversity of stakeholders increased and added complexity to the systems. It was soon clear that generating knowledge and exchanging information was not enough to promote agricultural innovation, which needed the congruence of other factors such as political support, private sector initiatives, farmer organization, market development and globalization. In addition, this implied interactions across local, regional, national and international levels. In several cases innovations started to occur as a result of a combination of the comparative advantages of public and private stakeholders, within which research organizations were just one among several players. As the changes occurred, scholars started to propose new theories aiming at explaining how multiple stakeholders interact and innovate to solve common problems. The innovation system approach (Hall et al., 2003, 2004; Hall, 2009) was proposed using principles developed in the private sector as an attempt to explain and promote agricultural innovation. The World Bank (2006) conceptualizes innovation systems as the group of organizations, enterprises and individuals that demand and supply knowledge and technologies, and the policies rules and mechanisms that are involved and influence how stakeholders interact for sharing, accessing, and using knowledge.

The innovation systems approach has been presented as a framework for helping stakeholders to understand the complexity of innovation processes, which is a common characteristic of current agricultural systems (Scoones et al., 2007). Chiriboga (2003) highlights some changes that illustrate such complexity; for example, the move from farm to territory as a unit of planning, from farm production to a diversity of rural activities and value chains, and from centralized government organizations to decentralized decision-making. Complexity increases even more when the goal is to have sustainable agricultural systems, and when interactions are needed across a wider local, regional, national and global scale, which also calls for renewed interest in inter and multidisciplinary viewpoints (Thomson et al., 2007).

Given the existing diversity and complexity of stakeholders, the question is how to develop innovations that can have a wider impact, particularly on alleviating poverty. Douthwaite (2002, 2009) has been looking at that issue and proposes two approaches called "learning selection" and "learning to innovate". The former focuses on the participation of users to enhance the design of the innovation so that it reaches a level of optimization sufficient to initiate a large-scale diffusion process. The author highlights the role of learning cycles through which the users implement or use a prototype of the innovation, assess it, make sense of their evaluations, and make decisions to improve the prototype. Through reiterative cycles of learning, the innovation accumulates the contribution of several users and reaches sufficient levels of optimization for moving to wide-scale adoption. The second approach suggested by Douthwaite stresses that people need to learn to innovate. The author updates the stages of the decision-making process for adoption proposed by Rogers (1962, 1995). Douthwaite puts those stages in more recent contexts and recommends ways to improve the stages of 1) "knowing" about an innovation through the creation of awareness of new opportunities, 2) "persuasion" through participatory research, 3) "implementation" and 4) "confirmation" through supporting adaptation mechanisms (participatory research also plays a key role in this stage). He then adds a new stage of 5) "learning and selection" where stakeholders should learn from their own and other people's experiences while adapting innovations.

Innovation approaches at the International Potato Center

Within the International Potato Center (CIP), approaches to innovation have also been changing since the 1970s. Initially, the linear approach of technology transfer prevailed, following the concepts of innovations diffusion theory. Then, in the 1980s CIP was a pioneer in developing participatory research approaches (Rhoades and Booth, 1982). CIP has maintained interest in participatory research, and this approach has been evolving in response to internal and external factors (Thiele et al., 2001). The participatory approaches are more in line with the theories related to knowledge and information systems and "learning to innovate" (Douthwaite, 2009). In recent years, some of CIP's work has focused on collective action and market chain innovation (Devaux et al., 2009), clearly in line with more recent theories on innovation systems.

This brief analysis of innovation approaches within CIP indicates that in the 1970s only one theoretical approach to innovation was dominant, but in following decades, several approaches started to coexist, and currently several are used according to the objectives of the different research areas at CIP. The innovation system approach, however, is becoming important because of the realization that interactions among several public and private stakeholders are needed for more effective interventions to develop potato and sweetpotato sectors. The coexistence and diversity of approaches within the same institution may be perceived as a challenge, but also as an opportunity because the use of diverse approaches to innovation is an essential ingredient for learning as indicated by Hall (2009).

Ortiz et al., (2009) describes some diagnostic work conducted in Bolivia, Ethiopia, Peru and Uganda using an innovation systems perspective. Although there were differences in the number of components and in the complexity of the potato innovation system across the pilot sites in the countries analyzed, a common feature was a limited intensity (in both number and frequency) of interactions among organizations already working on potato. This means, for example, that some non-governmental organizations (NGO) which have an important presence in countries such as Uganda and Peru, do not coordinate well among themselves or with government and private sector organizations and vice versa. Another common feature was that the main sources of potato-related information in general are other farmers (relatives, neighbors and friends), which indicates a relative absence of interactions with external sources of information. This work suggests that improving the frequency and quality of interactions among stakeholders would add efficiency to the innovation system because it would promote information sharing and inter-organizational learning.

The lack of interactions among organizations is a common feature in developing countries. One way of solving this problem is by promoting networking and collective action for fostering market chain innovation, which is the work that the CIP's partnership program called "Papa Andina initiative" is conducting in the Andean Region (Devaux et al., 2009). This initiative has developed specific methodologies to improve interactions, for example, the participatory market chain approach – PMCA (Bernet et al., 2006), which facilitates communication, negotiation and collective action among representatives of different sectors of the potato value chain (see other papers on this topic presented in the Symposium). One of the key features of this work is that market-oriented innovations such as new potato products developed for the market require to be complemented by other technical and institutional innovations according to the context. Attending to the demands for innovation that new commercial potato products generate (for example, better seed production, crop management for ensuring sufficient volumes for the market and improved postharvest handling) requires that research and development oriented organizations, both public and private, interact in a better way. In addition, depending on the demands and contexts, not only technical innovations may be required, but also innovative organizational arrangements, such as platforms that promote contacts, communication and negotiation among organizations, including and prioritizing farmer organizations. The Papa Andina initiative represents a clear case illustrating the innovation system approach, where good innovations have emerged from the interactions among a diversity of stakeholders with different but complementary comparative advantages (Devaux et al., 2009; Ordinola et al., 2009). Promoting and catalyzing effective interactions is also a goal in seed-related interventions in Africa, where CIP's current projects aim at developing effective interactions among government, NGO, private and farmer organizations. Preliminary results indicate that unless there is an effective coordination among these stakeholders, promoting seed-related innovations will be unsustainable. Lessons from other studies (i.e. Richards, 2009; Van Mele, 2009) indicate that for promoting agricultural development, the combination of technological, methodological and (inter) organizational innovation may be required depending on the context.

Some challenges to promote innovation in the 21st Century

Theoretical approaches to innovation have been changing over the years, evolving from the linear and relatively simple approach of innovation diffusions to a more complex and as yet still not sufficiently explored approach to innovation systems. Simple approaches to innovation seemed to fit well with the relatively simple contexts in which they were used, meaning the existence of large, government centered research and extension systems which were common in developing countries some decades ago. More recent theories, such as the innovation system approach fit well with the increased number and diversity of stakeholders involved in agricultural innovation currently. However, complexity in the systems has also increased and there is a need to draw from the theory more practical methodological approaches to support project design and implementation. This is critical for the more efficient promotion of root and tuber crops, which have not been appreciated in the past, but are now receiving renewed attention because of their importance for food security and income generation

Recent theoretical approaches, such as the innovation systems approach (Hall et al., 2003, 2004; Hall, 2009) have attracted a lot of attention, mainly because they fit into the current context of multiple stakeholders involved in innovation processes. It makes sense to use this approach to understand how these stakeholders contribute to innovation and what are the limitations faced by the systems. It also helps to understand the interactions not only among stakeholders but also among disciplines and levels; for example, within research, capacity building, private sector, market and policy, at the local, regional or national levels. An example of the use of the approach for understanding the potato innovation systems (Ortiz et al., 2009) was described before. However, one challenge for applying the innovation systems approach at field level is the lack of practical methods for promoting collective action among diverse stakeholders, which in many cases may not want to interact or act collectively. In other words, the "how to" is still underdeveloped in the innovation systems approach. Hall (2009) goes some way towards recognizing this and indicates that innovation systems should not be seen as an approach but as a metaphor for "innovation diversity". Therefore, for effective promotion of innovation, diverse approaches would be needed. He recommends that one possible way to go is to leave diversity to emerge and learn from that diversity. Examples of diverse approaches under development and used in the Andes to promote innovation include the PMCA approach (Bernet et al., 2006) and other commercial, institutional and technological innovations developed through collective action (Ordinola et al., 2009).

How to learn from a diversity of experiences becomes another challenge. As highlighted by Douthwaite (2009), learning from existing experiences, extracting lessons and promoting the best practices is an essential way to promote innovation. Andrews (2000) reaches a similar conclusion while making a retrospective analysis of what has worked or not in integrated pest management strategies. Observing and helping people to transform implicit knowledge into explicit knowledge can facilitate organizational learning (Nonaka, 1994). In addition, creating collaborative, inter organizational environments through, for example, participatory research helps to promote organizational learning, as has been observed in a long term collaborative experience between CIP and CARE in Peru (Ortiz, 2008). One of the lessons of this study is that unless learning experiences are purposefully created with the participation of at least two organizations with different but complementary comparative advantages, then it is difficult to learn from each others experience or from the collaborative experience. However, for this to happen, organizational learning activities should be included formally in project design and implementation. In addition, a change in the way donors finance some projects would be needed because, in general, donors want to claim that their investments generate specific benefits for people (this is called attribution). Difficulties regarding attribution would arise for donors who finance projects oriented to learning from good and replicable experiences developed by other donor investments. Examples of existing experiences include: networking, the use of information and communication technologies, platforms, participatory methods, inter-organizational learning, value chains and demand-lead research.

Positioning root and tuber crops in a competitive way also involves challenges; for example, promoting the participation and interaction of public and private organizations with different comparative advantages (research, development, processing, trade, policy, information management, etc.). Under this context, both national and international research organizations face the challenge of finding ways to contribute more efficiently to existing and dynamic innovation systems. In addition, how to ensure that the resulting innovations benefit the poorest sectors among producers and consumers and not only the stakeholders involved in the innovation process is another challenge.

Managing interactions and improving their quality is a challenge in itself; the higher the number of stakeholders, the higher the need for quality interactions in order to increase the efficiency of the innovation system. But at the same time high quality interactions require higher investment (Figure 1). In several cases, there are already valuable experiences from which lessons could be extracted and used.

Organizations need support to make sense of their own experiences, document their lessons, and promote forums for information exchange. Hence, financing learning-oriented projects, which could help organizations with different capabilities to work together and learn from their own experience, becomes another challenge. In addition, there is the need to, develop practical approaches to deal with complexity, dynamism and rapid changes, such as those caused by the climatic, food and financial crisis. This is one of the main challenges of the new approaches applied to innovations. Research organizations, not only focusing on technological, but also methodological and organizational innovation, have a renewed role to play in helping stakeholders to cope with such accelerated changes.

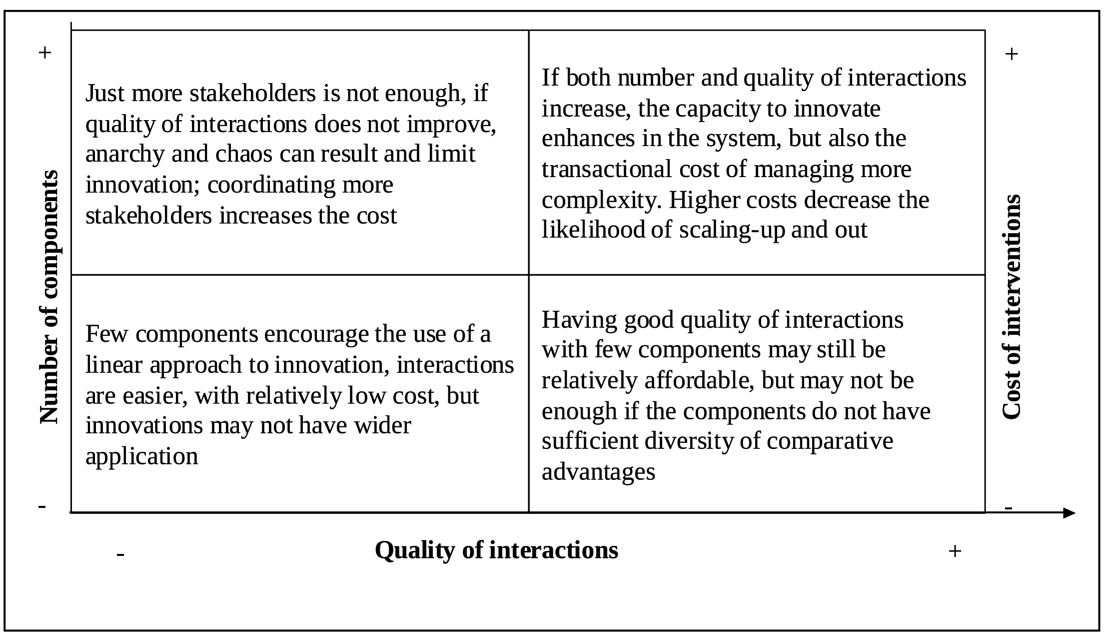

Figure 1. Potential relationship between the number of components, quality of interactions and costs for enhancing the efficiency of innovation systems.

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Educational innovation for Ugandan capacity development: Lessons from a new OFSP school book

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Abstract

This paper suggests more and better quality learning about Orange-Fleshed Sweetpotato (OFSP) in the context of school or community gardens and broader food/agricultural systems has the potential to strengthen personal, institutional and community innovations and capacities for reducing extreme poverty, hunger, malnutrition and environmental degradation. It can also help enhance the quality of educational systems, curricula, and teacher training while supporting entrepreneurial innovation and food security. This paper examines such ideas in theory and practice discussing implications of a recently published (2009) school-book in Uganda - ***Growing orange-fleshed sweetpotato for a healthy diet. A supplementary learners' resource book for upper primary schools.*** The paper discusses how the book is currently being used as well as results of an informal participatory evaluation of the school-book in selected pilot schools. It further identifies additional learning resource needs and capacity development challenges. Theoretically the paper presents an interdisciplinary approach to integrate educational, agricultural and food systems theory, research and practice. It further reviews related new participatory research planned to systematically study student, teacher and parents' learning issues, innovations and capacities for understanding or growing OFSP in food and community learning systems while lessons from the book are adopted, revised, applied and scaled-up.

Keywords: Orange-Fleshed Sweetpotato (OFSP), Uganda, Agricultural Education, Schools, Community Learning

School gardens history and OFSP education in Uganda

As early as the 1920s and 1930s Uganda's national education system had school gardens. However, these were not always popular since they were hard work for pupils and teachers often used them as punishment (hard labor). Although 90 per cent of the population had been engaged in agriculture many parents also did not appreciate agricultural education. They wanted their children to be better educated in clerical or vocational skills or more potentially prestigious jobs or careers with better incomes in cities away from rural farms. Other long-standing problems stemmed from the colonial history of agricultural education in Uganda which encouraged learning modern sciences mainly to produce key cash crops. This discouraged farmers from planting traditional crops and using ancient husbandry practices or knowledge (Ssekamwa, and Lugumba, 2001, pp. 44-47, 51-52, 65-68; Mubiro and Ojacar, 2001).

Despite Uganda's long history of agricultural education children and families still lacked food security, adequate nutrition and sufficient knowledge or economic incentives to change their circumstances. Many related activities continued to be unpopular among students, teachers and parents. In response to some of these challenges recent projects used schools (and their gardens) to demonstrate growing, harvesting and production techniques while transferring new agricultural technologies and innovations to influence household decision-making, health and community livelihoods. One major new initiative beginning in 2004 was *"Promotion of Orange-Fleshed Sweet Potato Varieties through Schools in Urban and Peri-urban Communities of Kampala"* (Schools OFSP Project). The project used eleven pilot schools in peri-urban Kampala as meeting places for training and learning with students, parents and farmers. It established OFSP gardens and taught rapid multiplication techniques (RMT) for sweet potato vines while also teaching production agronomy and post-harvest processing. It used various learning approaches including drama, farmer-to-farmer extension and posters distribution for training and knowledge transfer. It monitored schoolchildren's home OFSP gardens/RMT plots and developed a training of trainer (TOT) manual to broaden potential audiences and impacts. Research has demonstrated that learning about OFSP as part of nutrition education in a formal science curriculum and non-formal community education has been a unique and substantive contribution to African agricultural development, poverty reduction, income generation and health. However, more work is needed to measure effectiveness or impacts of OFSP school learning and other food-based interventions, or how knowledge or life-time preferences and technologies are transmitted to households (Andrade et al., 2009, p. 82, 86; and Loechl, et. al. 2009).

The "Schools OFSP Project" ended in 2006 but CIP still later published a school-book (Kapinga, Byaruhanga, Zschocke and Tumwegamire, 2009). CIP scientists, local experts, Uganda school teachers the National Curriculum Development Center and others contributed (through a participatory and community-oriented approach) to the content of a supplementary reader (mainly for teachers' use) to upper primary curriculum. In early 2009 some 500 copies were published and 220 copies distributed for classroom piloting in the same eleven peri-urban Kampala schools from the earlier project.

Initial OFSP schoolbook observations and perceptions

With support from the CIP Uganda office CIP's Capacity Strengthening Department (CSD) in June 2009, conducted a field visit to: 1) better understand how CIP's new schoolbook was being used; 2) gather general perceptions of the book's value as well as types of other educational needs and learning resources expressed by users; 3) explore how this book and related materials could be better integrated with the national curriculum while supporting quality learning about agriculture, health and environment; and 4) assess the viability of a related new education research and agricultural development project. We visited three of the eleven peri-urban schools in the "Schools OFSP Project" which received copies of the book in early 2009 and were now using it in classes. We also visited several possible partners or donors who might collaborate in designing, supporting or implementing a new inter-disciplinary research and capacity development project. The visit was not conducted as a rigorous formal research initiative with quantitative data collection. Rather it was intended as an informal information gathering and consultation activity producing preliminary qualitative data to be used in a more formal research design. Observations below are without direct attribution or intended as a definitive and conclusive. However, the present paper can serve as a discussion document after revision, then circulated among potential partners to help facilitate a dialogue on future funding proposal and project.

School Observations and Discussions Overview. Although 220 copies of the OFSP book were evenly distributed to all eleven original Kampala schools, time for this June 2009 mission only permitted a visit to three - Kitebi Primary School; St. Andrew's Komamboga Primary School; and Ttula Church of Uganda Primary School. Informal discussions raised and observations among them were similar or overlapped regarding the obvious value of the present OFSP book, school gardens and future learning needs.

Value of OFSP Schoolbook. With respect to the immediate value of CIP's OFSP book some teachers clearly found it useful as a supplement to the existing Upper Primary (P5 & P6) curriculum in which agriculture and horticulture is already taught. We observed one teacher's class lesson on natural enemies of agricultural pests and diseases illustrated through information in the book. He used the OFSP book referring to the text's pictures, explanations and drawings to illustrate bigger concepts while children were actively engaged in questions and answers (see Pics 1, 2 and 3 in Appendix below). Some teachers had contributed the OFSP book content so were also happy to see it now available. Discussions with Headmasters and some teachers confirmed that the book was a valuable complement to the existing science curriculum. One teacher praised the book for showing (still in light of some negative attitudes among parents and students) that farming did not have to be a "punishment" but could be a "source of income."

School-Community Gardens. CIP's 2009 OFSP book evolved out of a school garden project. Many of the original eleven schools facilitated OFSP vine multiplication in communities so they were not just children's or teachers gardens, but de facto community gardens and learning centers based in schools. Some teachers during our visit reported such activities made the community more interested in the school, while parents also learned by observing gardens and gaining experience from children. But after the initial project ended OFSP growing in some school gardens had not continued well (Pic 4 below). One apparent challenge was lack of a dedicated manager to tend the gardens and or supervise and facilitate ongoing activities with communities beyond the school curriculum or calendar alone. In some cases school gardens were overgrown, vine multiplication systems had been discontinued or broken down while students, their families and communities had lost some vine growing knowledge as well as associated health and income benefits from OFSP. However, new research is needed to assess specific knowledge and economic outcomes from past OFSP growing in school gardens or as part of an ongoing monitoring and evaluation of any new initiatives.

Future Needs Identified (Learning Resources & Support Tools). *These schools clearly found this new OFSP book valuable. However, our* discussions raised t*hree main themes. First was demand for more copies,* provided to the schools we visited, but also that the book be distributed to all schools in the country. *Second was identification of additional learning resource needs including revisions to the OFSP book;* lesson guides for teachers; and simpler, shorter books for students. *Third, beyond this book alone, there was a clear demand for complementary materials* on roots and tuber crops generally, or adding beans and leafy vegetables, or livestock to complement the official curriculum and demonstrate more rounded nutritional, ecological or food systems education. One related suggestion was that other school books could cover more crops, intercropping practices, and nutritional information for balanced diets and food security. Building on previous successes this could still be linked to better understanding of agricultural techniques and vine multiplication in a revived school garden better linked to community learning (with students key knowledge transmitters) and income generation. Some teachers also expressed that, in any future project, that they need garden tools (which most schools can't afford) so children can do practical demonstration work of classroom lessons. .

Research and Capacity Development Partner Discussions

Aside from visiting schools we discussed potential collaboration in a new OFSP related inter-disciplinary research and educational capacity development project with other national, regional and international partners or donors. These partners variously identified seven key themes for future research and design of a new project, including: 1) better integration of OFSP learning with education about other crops into the formal national curriculum, currently undergoing revision; 2) a more holistic and comprehensive approach linked to national curriculum reform; 3) linking these to other education-related initiatives such as farmer extension programs; 4) linking agricultural research and teacher training with broader capacity development efforts; 5) developing complementary resources and support systems such as teacher's guides and orientations as part of pre-service training in teachers' colleges; 6) doing education research itself (not just agriculture research); and 7) being more strategic about targeting the whole country with new learning resources.

With respect to national curriculum integration and reform, among practical suggestions for developing or monitoring on any project or ongoing program would be how to introduce OFSP themes into various parts of the curriculum and how to prepare lesson plans and teach the topic in relation to different subjects (science, math, health, culture/religion, etc., not just agriculture). The curriculum should also better provide not just theoretical knowledge but life-skills. Future research needs to study teachers' lesson plans and build in an onsite monitoring, record keeping and guidance system to assess what was taught and how to improve teaching.

A future OFSP-related research project might be a capacity building initiative for education researchers and teachers, as well as for agricultural researchers, professors and students. Graduate research fellows might finish a related education or agriculture thesis. University Schools of Education might help with training as well as research for science and agricultural teachers while graduate students do research degrees (Masters or PhD) on education topics with interdisciplinary approaches including study and teaching of agro-ecological and environmental issues. OFSP text themes could be also be adapted for other teaching or learning purposes and audiences. The existing text could be repackaged in parts using simpler resource materials, particularly since farmers only have 60 % literacy and need different types of learning materials including posters and non-traditional delivery systems. Children's (and adults') agricultural learning might also more holistically involve livestock with better nutrient cycling, natural (organic) fertilizers, etc., OFSP as animal feed, and explore potential for new income and livelihood opportunities. Learning could better integrate educational, environmental and agricultural research including cultural factors in OFSP use. Complementing school feeding or nutrition awareness programs new work should target rural areas, especially poorer Northern Uganda to broaden livelihood sources assist with vines multiplication etc. OFSP school book themes also need to target different class room grade levels, and be translated into up to 10 different native languages, address gender, environment, etc.

Such themes were discussed in meetings with Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA); Department of Science and Technical Education (DOSATE), Makere University; Makere University Centre for Continuing Agricultural Education (***CAEC*****);** National Curriculum Development Centre (NCDC), Uganda; Regional Universities Forum for Capacity Building in Agriculture (***RUFORUM***); Ugandan National Commission for UNESCO; United Nations Food and Agricultural Organization (FAO); and World Food Programme (WFP). We also visited the United States Agency for International Development (USAID), since prior to this field visit informal conversations with the Bill and Melinda Gates Foundation BMGF) suggested we should consult USAID as a potential partner/donor for a new project

OFSP school book lessons - conclusions and next steps

This present paper is a "work in progress." The findings are not definitive or conclusive. But it seems clear that CIP's recently published OFSP schoolbook was an educational innovation with clear value even with limited distribution so far. Future work might expand its thematic scope, scale and availability complemented by new research. As should be evident above selected schools as well as potential research partners consulted in June 2009 raised common themes, noted similar needs and helped clarify some key research and development priorities. Preliminary analysis and feedback in sum suggests at least three principal themes and identified community needs should be considered as lessons for developing any new project.

1. New Educational and Resource Needs

- Demand for more OFSP books distributed across the country.
- Additional learning resources needed including OFSP book revisions, teachers' lesson guides, and simpler books for lower student levels
- Demand for other agricultural/horticultural learning materials on other crops, intercropping and nutritional, ecological or food systems education
- Rural/regional targeting of learning resources beyond urban centers.
- School garden tools for children to better demonstrate classroom lessons.

2. Interdisciplinary Educational-Agricultural Research and Teacher Training

- Participatory research to study student, teacher and parents' learning issues, innovations and capacities to understand or grow OFSP and other crops
- Capacity development for research on agricultural and science education (in cooperation with University Education Departments)
- Support for graduate thesis work as well as professors to design and conduct education (not just agricultural) research

3. Capacity Development (scientific, teacher-educational, farmer, community)

- Collaboration with regional organizations to scale-up/out
- Support school gardens with a holistic education approach in "community learning centers" to broaden sources of family and farmer livelihoods.

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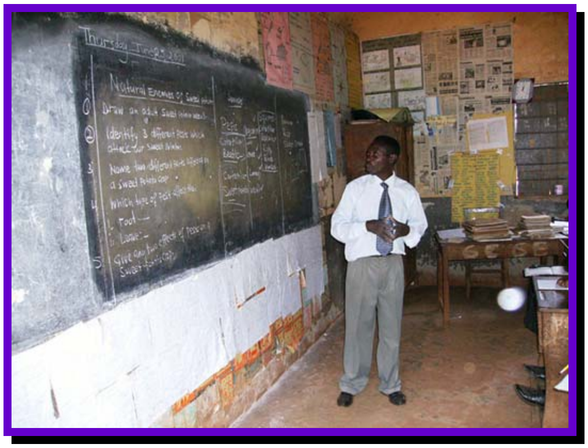
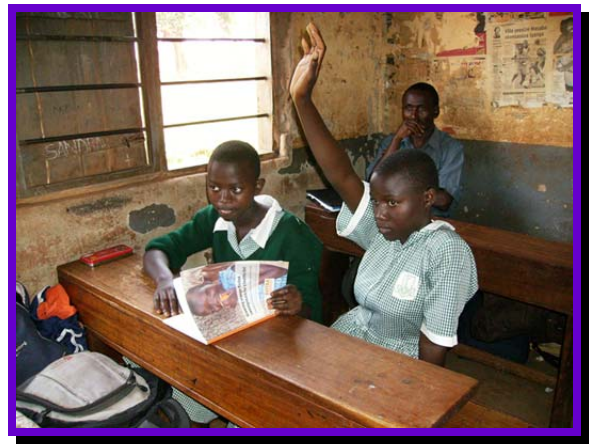
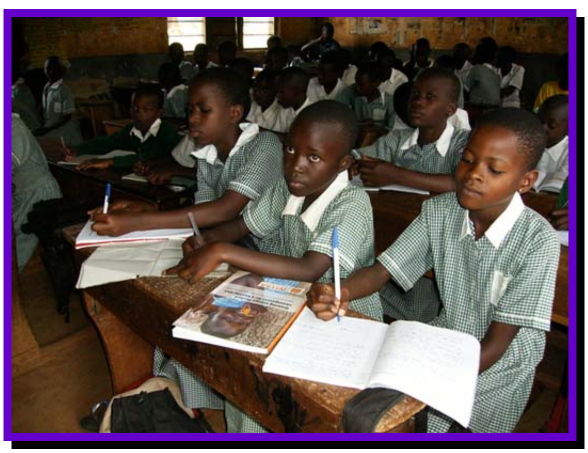
Appendix 1 - Pictures



Pic 1. Kitebi Primary School Teacher (P 5-6 Class Lesson on Agricultural Pests and Diseases – Sweetpotato case)



Pic 2. Kitebi Primary School P 5-6 Class Lesson (Students consulting the OFSP Book while answering teacher questions on pests and disease.)



Pic 3. Kitebi Primary School P 5-6 Class Lesson (Students listening to teacher with CIP/OFSP book in P 5-6 Class Lesson on Pests and Disease)

Pic 4 St. Andrew's Komamboga Primary School Garden (Sweetpotato section inspection with children lookingon)

Involving schoolchildren in orange-fleshed sweetpotato promotion – Achievements in Kampala

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Abstract

Schoolchildren are the future parents and targeting them with Orange-Fleshed Sweetpotato (OFSP) interventions could influence lifetime food preferences. This paper presents results on changes in schoolchildren's OFSP awareness, knowledge, production and consumption when interventions are primarily agricultural, primarily nutritional, or combined. Schools were used as venues to disseminate OFSP production technologies for roots and vines (AG) and nutrition education (NE) to surrounding communities. In 3 divisions of Kampala, Uganda, 15 schools were enrolled in NE (grp3), AG (grp2) or both (grp1), with 5 schools in one control division (grp4). Depending on the intervention group, primary 3-7 schoolchildren were exposed to OFSP Rapid vine Multiplication Technologies, given vines to grow at home and involved in up to three NE sessions on general nutritional facts, OFSP and vitamin A. Post-post comparisons were carried out using Chi-Square. The results demonstrate that AG and NE raised schoolchildren's awareness of OFSP. In intervention groups all schoolchildren had heard about OFSP (39% grp4). All schoolchildren in grp1 and 2 cited at least one vitamin A rich food (82% grp3, 61% grp4). More schoolchildren in grp1 (77%) than in grp2 (60%) planted vines received at school. Schoolchildren reporting consumption of OFSP prepared in home was highest in grp1 (100%) and in grp3 (91%) compared to 56% in grp2 and 75% in grp4 ($p=0.006$). Results demonstrate that the impact is greatest when schoolchildren participate in both interventions. More research is needed to evaluate whether schoolchildren are effective entry points for knowledge and technology transmission to other household members.

Keywords: Orange-fleshed Sweetpotato, vitamin A, targeting schoolchildren, primary schools, urban and peri-urban farming.

Introduction

Vitamin A deficiency (VAD) is a major health concern in many low-income populations with high mortality rates, including Uganda (Ezzati *et al.*, 2002; Uganda Bureau of Statistics and Macro International Inc., 2007). It is an important cause of morbidity and mortality, impaired night vision and, in more severe manifestations, of blindness and increased mortality among young children (West, 2002). In the last Ugandan Demographic and Health Survey of 2006, about 20% of children under five were found to have vitamin A deficiency (<0.825 µmol/L of Retinol-Binding Protein) (Uganda Bureau of Statistics and Macro International Inc., 2007). Vitamin A deficiency disorders are a serious public health concern in Uganda.

One option for controlling and preventing vitamin A deficiency is biofortification. Traditional staple food crops with low nutrient content are substituted with improved, nutrient-dense varieties. Orange-fleshed sweetpotato (OFSP) is an example of a biofortified crop. The beta-carotene content is enhanced through plant breeding to the point where impact on the vitamin A status can be achieved (Bouis, 2002). This strategy is particularly promising for poor rural households that cannot access purchased fortified food products but could grow OFSP.

Children under five years of age are at greatest risk of VAD. However, other target groups might be considered for many reasons. For example, targeting school children may be an effective means for reaching large numbers of households through a centralized location if children prove to be effective transmitters of technologies from school to household (Andrade *et al.*, 2009). This latter aspect was the key feature of the project: 'Promotion of

Orange-Fleshed Sweet Potato Varieties through Schools in Urban and Peri-urban Communities of Kampala" (Schools OFSP Project) that was implemented from 2004 to 2006.

Approach and methods

The schools OFSP project was started in Kampala in 2004 and implemented by a multi-stakeholder partnership led by the Department of Agricultural Extension, Makerere University. The aim of the project was to contribute to widespread production of two OFSP varieties ("*Kakamega"* and *"Ejumula*"), using an approach of training primary school teachers and primary 3-7 schoolchildren as well as men and women farmers from communities surrounding 11 selected schools in the divisions of Kawempe and Rubaga of Kampala city. The training focused on methods and techniques of rapid multiplication (RMT) of sweet potato vines, as well as production agronomy and some aspects of post-harvest processing of the OFSP varieties. This project was a build-up and adopted an approach of another project carried out in Kampala from 2002 to 2003 entitled "Schools as Technology Dissemination, Extension Support and Commercial Seed Production Centres for Urban and Peri-Urban Farming Communities", which sought to assess the appropriateness of using schools to produce and make available planting materials to urban farming communities (Miiro et al forthcoming).

The project used a variety of methods including presentation-question-answer meetings, on-plot demonstrations, drama, farmer-to-farmer extension, farm station visits and distribution of posters to train and transfer knowledge and technologies to beneficiaries. The school was the principle meeting place for training and learning purposes. OFSP gardens and RMT plots were established at the schools for demonstration as well multiplication of vines. The schoolchildren maintained them under the supervision of the trained teachers. In addition, schoolchildren received vines to grow OFSP at home (Kapinga *et al.*, undated).

Realising that the Schools OFSP project did not have a nutrition component beyond 'sensitisation', Urban Harvest, CGIAR's system wide program on urban and peri-urban agriculture, joined the partnership to compliment the agricultural interventions with deeper nutrition education to build synergy for increased adoption, consumption as well as intra-household distribution of OFSP. Nutrition education and training started in February 2005, one year after commencement of agricultural interventions, and concluded in December the same year. In each school, three training sessions were carried out. The first one covered general nutritional facts and introductory aspects of vitamin A in health, the second one covering food and non-food sources of vitamin A while highlighting importance of OFSP. The last session concentrated on attitudes to vitamin A capsule supplements, mosquito net use, other attitudes and practices as well as the practical cooking classes.

The interval between training sessions averaged 4-6 weeks. Training of groups of 30-40 participants on average followed a facilitated group discussion approach. Demonstrations, posters and calendars depicting plant and animal foods rich in vitamin A were also used to communicate nutrition education messages. Participants underwent practical classes to formulate recipes, prepare and cook enriched dishes for young children. Community members and primary 4-6 schoolchildren were trained separately on the premises of the school but during the same visit.

The nutrition education component was added to the schools OFSP project in Kawempe Division (Rubaga Division: remained with agricultural intervention only). Another two divisions were included: Nakawa Division, where nutrition education was introduced (no agricultural intervention) and Makindye Division, which acted as a relative control where no interventions were undertaken. A cross-sectional survey was conducted from July to September 2006 to compare areas 'with' and 'without' different interventions (post-post comparison). The intervention design allowed assessment of the separate and combined impacts of the agricultural and nutrition education interventions (see Table 1).

Four types of questionnaires were administered in the cross-sectional survey: food frequency questionnaire covering the past 7 days; questionnaires on vitamin A-related Knowledge Attitudes and Practices (KAP); 24-hour food consumption recall and anthropometric measurements of children under 5 years of age. To understand the effect of nutrition education on vitamin A-related knowledge, attitudes and practices, one questionnaire was administered to the main respondent identified as the person from the household who most attended nutrition education and/or agriculture sessions (mostly the principal woman of the household) and one questionnaire to a child from the respondent household who was a schoolchild in one of the intervention schools. The data presented here focus on the schoolchildren KAP.

Table 1. Comparison groups created by agricultural and nutrition education interventions

Group	Division	Type of interventions	Number of participating schools
1	Kawempe	Agricultural Technologies/Extension andNutrition Education	5
2	Rubaga	Agricultural technologies/extensions only	5
3	Nakawa	Nutrition Education only	5
4	Makindye	No intervention (control division)	5

Descriptive analysis of the data was conducted. Inferential testing for intervention group was done using Pearson's chi-square test.

Results and discussion

The sample included 85 schoolchildren (Group 1: n=25; group 2: n=10; group 3: n=22; group4/control: n=28) mainly from primary four to six. Schoolchildren from grade one and two were not targeted by the nutrition education as they were considered too young. The average age of the schoolchildren in the sample was 12.55 years (from 7 to 16 years). 61% of the schoolchildren in the sample were female and 39% male.

Schoolchildren's OFSP awareness

Eighty percent of all schoolchildren had heard about OFSP. Stratification by group shows that all schoolchildren respondents in the three intervention groups had heard about OFSP, but only 39% had heard about it in the control group (p=0.000). In the intervention groups, the majority who had heard about OFSP had heard it from the teacher or the OFSP project people. In the control group, most of the schoolchildren had heard about OFSP from the teacher or the parents (p=0.000).

Overall, 71% of the schoolchildren had seen any OFSP root. There are statistically significant differences between the groups. All schoolchildren respondents in intervention groups 1 and 2 had seen OFSP at school, either shown by the OFSP project team or by the teacher in class. The majority in group 3 (82%) had seen OFSP, mainly at school but also in the market and at home (harvested from the garden). But in the control group only 25% had ever seen OFSP. None of those who had seen OFSP in this group had seen it at school.

The majority of those who had seen OFSP and who were in agricultural intervention groups (1 and 2) knew and could name both Kakamega and Ejumula (>90%). In group 3 (nutrition education only), 78% did not know any OFSP variety by name. This is not surprising since the nutrition education material did not differentiate between different OFSP varieties. In the control group, none of the respondents was able to name an OFSP variety (p=0.000).

Schoolchildren's Vitamin A Knowledge

44% of schoolchildren were able to indicate one vitamin A rich food and 39% two vitamin A rich foods. 18% did not know any vitamin A rich food. This varies significantly between the different groups (p=0.003). In intervention groups 1 and 2, all schoolchildren were able to name at least one vitamin A rich food and about half of them could cite two. In group 3, 18% were not able to indicate any vitamin A rich food and in the control group, this percentage rose to 39%.

Overall, more than half of the schoolchildren (64%) were not able to cite any disease related to vitamin A deficiency. 33% could name one disease and 4% two diseases. This varies between the different groups, but the differences are not statistically significant (p=0.062). The percentage of those who did not know any disease is highest in the control group (86%) and lowest in group 3 (41%).

OFSP Production

The majority of schoolchildren who attended schools that were part of the agricultural intervention (group 1 and 2) had received OFSP vines from the school to take home (88 and 100% respectively). Only a fifth of group 3 children (nutrition education only) had obtained vines and none in the control group.

Of those schoolchildren who have taken home OFSP vines from school, overall 69% made their own nursery beds (group 1: 82%; group 2: 60%; group 3: 25%). The differences are statistically significant (p=0.057). The majority of those who made their own nursery bed in group 1 and 2 also planted their own sweet potato crop. In group 3, the one schoolchild who had made a nursery bed did not plant own sweet potato crop, whereas some schoolchildren in each group had not made a nursery bed, but planted their own SP crop (total of those who planted: group 1: 77%; group 2: 60%; group 3: 50%). The majority of schoolchildren respondents who had received OFSP vines at school, but had not planted their own SP crop said that they gave the vines to the parent/guardian who planted them.

Overall, 60% of those schoolchildren who had planted their own SP crop indicated that they were given the place where to plant them by their mother and 32% by another adult. 32% received help from their mothers, another 32% from their sisters/brothers, and 28% had not received help at all in planting the vines. Only very few schoolchildren respondents (13% overall) did still have a RMT nursery at home at the moment of the survey. Different reasons were mentioned for not being able to keep an RMT nursery at home: the vines had wilted due to drought; they had never established a nursery, they had planted directly in the garden; the bed was destroyed by cattle/animals; they had used all the vines from the previous nursery and had not yet established another one; and parents harvested the roots from the nursery and uprooted the vines. There are no statistically significant differences between the groups.

OFSP Consumption

Overall, 57% of the schoolchildren said that OFSP had been cooked and served in their homes. There are statistically significant differences between the groups (see Table 2). The percentage is highest in group 1 and lowest in the control group. Of those in whose homes OFSP had been cooked and served (n=48), 88% reported having eaten from the boiled or steamed OFSP. Within each intervention group, the share of children in whose homes OFSP was prepared and who have personally eaten it, is highest in group 1 (100%) (see Table 2); in group 3 the majority, in the control group two-thirds and in group 2 just about half of the children in whose homes OFSP was prepared have tried it themselves.

Table 2. Consumption of OFSP by intervention group (% within intervention group)

	Group 1	Group 2	Group 3	Control
OFSP prepared in home (n=85)				
Yes	96.0	90.0	50.0	14.3
No	4.0	10.0	50.0	78.6
OFSP personally eaten (n=48)				
Yes	100.0	55.6	90.9	75.0
No	0.0	44.4	9.1	25.0

OFSP prepared: F-value=42.64, p-value=0.000
OFSP personally eaten: F-value=12.51, p-value=0.006

Of those schoolchildren who had eaten it (n=42), 93% said that they would prefer OFSP if they were to choose between eating OFSP and WFSP, mainly because OFSP contains vitamin A, tastes better and is sweeter. There are no statistically significant differences between the groups.

In summary, the project interventions have resulted in creating awareness for OFSP among schoolchildren. Schoolchildren had heard about OFSP, had seen OFSP roots and were able to name two OFSP varieties. Best results were demonstrated for schoolchildren who participated in the agricultural interventions (group 1 and 2).

Similarly, for vitamin A knowledge participation in the agricultural intervention seemed to be important. In terms of knowledge of diseases caused by vitamin A deficiency, more than half of schoolchildren of group 3 (nutrition education only) mentioned at least one disease, whereas less schoolchildren in group 1 and 2 were able to cite one or two diseases related to vitamin A deficiency. Schoolchildren who participated in the agricultural and nutrition education activities were more active in establishing nursery beds and planting OFSP and more likely to eat the boiled and steamed OFSP roots prepared in their homes. The nutrition education had also a positive influence on consumption in group 3 – most of the schoolchildren in whose homes OFSP had been cooked have reported eating it, but the lack of access to vines in this group results in limited OFSP production in the homes.

It is surprising that schoolchildren in group 2 (agricultural intervention only) seem to have quite good knowledge on vitamin A. This might be due to the fact that sensitization activities on the nutritional value of OFSP were conducted as part of the agricultural interventions. Schoolchildren were trained on OFSP by teachers, who had been trained by scientists from the national research institutions. The training focused on establishment and management of RMT, OFSP agronomy, post harvest handling and utilization, but included some aspects on importance of vitamin A, vitamin A deficiency symptoms and sources of vitamin A (Miiro *et al.*, 2006). In addition, schoolchildren may have participated in open promotion campaigns on nutritional and other benefits of OFSP that were held in schools in order to raise general awareness by the communities (Kapinga *et al.*, undated). Schoolchildren were in general much more involved with the agricultural activities than with the nutrition education activities. They maintained the OFSP and RMT plots and were involved in day-to-day activities such as weeding, watering etc. We don't have data on how many times schoolchildren participated in nutrition education sessions in group 3. Sometimes the sessions were conducted on weekends when schoolchildren could not attend, but every schoolchild has participated at least in one session, but up to three sessions (A. Lubowa, personal communication).

A key feature of the project's approach was to use schoolchildren learning at school in a practical and active way and then expect transfer of technologies and innovations to their households of origin and some influence on household decision making. With the current dataset we are not able to evaluate whether the transfer of technologies to the schoolchildren' households has happened and whether the decision making with respect to OFSP has been influenced. The data do not allow assessing the levels of adoption by parents/communities that can be specifically attributed to schoolchildren's efforts.

Conclusions

The results demonstrate that the agricultural and nutritional interventions raised schoolchildren's awareness of OFSP, improved their knowledge on vitamin A, encouraged planting and consumption of OFSP and led to changing consumption preferences related to SP. Results also show – as expected - that the impact is greater when schoolchildren participated in both interventions. Schoolchildren are the future parents of the world and addressing them is an opportunity to influence lifetime food preferences. Therefore, schools are useful venues for OFSP related interventions. Another advantage of using schools as venues is that schools are regarded as neutral places where communities can meet, share and exchange knowledge (Kapinga *et al.*, undated). However, more research is needed to evaluate whether schoolchildren are effective entry points for knowledge and technology transmission to other household members, and whether this has an impact on OFSP uptake in schoolchildren's households.

Acknowledgements

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Out-scaling and up-scaling orange fleshed sweetpotato technologies: the potential role of innovation platforms

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An innovation systems (IS) perspective is increasingly being used as an organising framework to support the application of research knowledge for desired socio-economic outcomes. The IS approach recognises that a broad participation and interaction of actors from public and private sectors is required for agricultural innovation to take place. This approach builds on a wide range of existing participatory technology development and transfer approaches. Under the Dissemination of New Agricultural Technology in Africa (DONATA), Orange Fleshed Sweetpotato (OFSP) project, Innovation Platforms for Technology Adoption (IPTAs) are being formed in Ethiopia, Kenya, Rwanda, Tanzania and Uganda. These aim to bring together relevant value chain stakeholders to develop institutional mechanisms that will support the up-scaling of OFSP technologies (e.g. new varieties, agronomic practices, and post-harvest activities). The paper presents results from a literature review illustrating current thinking in a number of areas including: how partnerships established to support agricultural innovation contribute to emerging typologies and theoretical frameworks for partnership research; how partnerships instigate institutional changes conducive to creating a space for innovation through increased interaction and social learning; what competencies and capacities are required for a partnership to contribute to innovation; and, how the bio-physical characteristics of OFSP might influence the type of partnership and institutional changes required to up-scale benefits to small-scale farmers. These results will be used to contribute to a design framework for a series of action research case studies to capture lessons on the experiences from the innovation platforms on up scaling OFSP.

Keywords: Partnerships Innovation Systems Orange-fleshed Sweetpotato East and Central Africa.

Introduction

Recent work across East and Central Africa (ECA) has shown that beta-carotene rich orange fleshed sweetpotato (OFSP) varieties with high dry matter content are acceptable to consumers (Anderson*, et al*., 2007; Andrade*, et al*., 2009; Mwanga*, et al*., 2009). Positive agronomic characteristics include: short maturation period, low labour requirements, and reliable yields under low input, marginal conditions. It is acknowledged that continued work is needed on breeding for disease resistance and drought tolerance. However, to date, less consideration has been directed towards understanding the institutional arrangements required to support the adaptive uptake and sustained up-scaling of OFSP which could contribute towards improved socio-economic benefit for small scale farmers. This requires research to gain a clearer understanding of whether and how multi-stakeholder partnerships can contribute to on-going technological, institutional and social innovations in different contexts.

Over the last 10 years there have been a number of initiatives to apply innovation systems theory to the institutional arrangements for agricultural research and development in developing countries. The agricultural innovation systems approach builds on earlier approaches for strengthening farmer participation and farmer organization, but also seeks to create linkages among a broader range of stakeholders within and beyond the agricultural sector. This is in part a reaction to the failure of the linear model of technology transfer (i.e. from researcher to extension agent to farmer) to deliver sustained and wide-spread benefits from research outputs to farmers. Interest in applying an innovation systems approach is also a reflection of the increasing complexity of agricultural research in a market driven global economy.

Under the Dissemination of New Agricultural Technology in Africa (DONATA), Orange Fleshed Sweetpotato (OFSP) project, Innovation Platforms for Technology Adoption (IPTAs) are being formed in Ethiopia, Kenya, Rwanda, Tanzania and Uganda. The IPTAs aim to bring together relevant value chain stakeholders to develop institutional mechanisms that will support the up-scaling of OFSP technologies (e.g. new varieties, agronomic practices, and post-harvest activities).

Objectives

The paper presents findings from a preliminary literature review to illustrate current thinking in the following areas:

1. how an analysis of partnerships established to support agricultural innovation can contribute to emerging typologies and theoretical frameworks for partnership research;
2. what types of partnership practices instigate institutional changes conducive to creating a space for innovation;
3. what competencies and capacities are required for a partnership to contribute to innovation;
4. how do the bio-physical characteristics of OFSP influence the type of partnerships and institutional changes required to out and up scale benefits to small-scale farmers.

Methods

This paper has drawn considerably from the bibliography compiled by Horton et. al. for their working paper for the International Potato Center (CIP): "Perspectives on Partnership: A Review of Literature Relevant to International Agricultural Research for Development" (Horton*, et al.*, in press). Their review has provided extensive coverage of different literatures on partnerships. The paper has also been fortunate to benefit from two recent workshops focusing on agricultural innovation. These were: "Innovation Africa: Enriching Farmers' Livelihoods" held in Kampala, Uganda in late 2006, (Sanginga*, et al.*, 2009); and "Farmer First Revisited: Innovation for Agricultural Research and Development", held in Brighton, England at the end of 2007 (Scoones and Thompson, 2009). The web-based materials and published books resulting from these workshops illustrate the current state of the art as well as emerging issues and concerns about the application of an innovation systems approach to partnerships for agricultural research and development. Additional materials were identified through web-based searches using the following key words: *innovation systems, agricultural innovation systems, innovation platforms*. The literature on partnerships and innovation is vast and covers different disciplines. This has led to difficulties in defining boundaries for the review. In this review the following definitions have been used:

1. *Innovation* is the first significant use of new ideas, new technologies or new ways of doing things in a place or by people where they have not been used before (Research-into-Use, 2008).
2. *Out-scaling* is the 'horizontal' spread of knowledge and adaptive uptake of technologies, processes and practices (e.g. to farmers or businesses at a similar level) (Research-into-Use, 2008).
3. *Up-scaling* is influencing decision makers at a 'higher' level to develop policies which provide a more enabling environment for 'scaling-out' [significantly increase the understanding of how the promotion and widespread use of particular research-based knowledge can contribute to poverty reduction and economic growth] (Research-into-Use, 2008).
4. *Institutions* are the sets of common habits, routines, practices, rules or laws that regulate the relationships and interactions between individuals and groups (Hall*, et al.*, 2005a).
5. *Organizations* are bodies such as enterprises, research institutes, farmer cooperatives and governmental or non-governmental organizations (NGOs) (Hall*, et al.*, 2005a).

The current review should be considered as work in progress to contribute to a theoretical framework and develop hypotheses to assess the contribution of different types of partnership models (e.g. the DONATA innovation platforms for technology adoption) to support innovation processes for the adaptive up-scaling of technologies. The paper is organized to discuss the findings for each objective in turn.

Results

Horton et. al. (in press) have conducted an expansive and illuminating review of the partnership literature for agricultural research and development. This assessed the current state of knowledge on partnerships and analysed how an improved understanding of the way in which partnerships function can also contribute to international agricultural research and development. The authors identified a number of professional literatures where partnerships have been studied for their contribution to agricultural research and development. They argued that these literatures have evolved in relative isolation from one another. This has therefore led to a situation where there is no broadly accepted theoretical framework through which to analyze the role and value of partnerships in different contexts.

Horton et. al. found that there has been limited empirical field work to test theoretical models on different partnering arrangements. They identified a range of issues that required further research for different levels of partnerships. These included:

1. which factors influence the performance of different types of innovation partnerships associated with CG centers and programs;
2. how partnerships are constructed by participating actors and how they are negotiated in practice;
3. how partnerships perform in terms of outcomes and value added, and evidence that despite high transaction costs working in partnership does add value.

How can an innovation systems perspective contribute to a typology and framework for partnership research

An innovation system has been defined as a network of organizations, enterprises, and individuals focused on bringing new products, new processes, and new forms of organization into economic use, together with the institutions and policies that affect their behavior and performance. The innovation systems concept embraces not only the science suppliers but the totality and interaction of actors involved in innovation. It extends beyond the creation of knowledge to encompass the factors affecting demand for and use of knowledge in novel and useful ways (World Bank, 2006).

The innovation systems framework developed by Arnold and Bell in 2001 (World Bank, 2006), focuses on six major domains. The first three consist of: the demand domain comprising producers (e.g. farmers) and consumers who are crucial as sources of innovation and in guiding the direction of innovation; the education and research domain, and the business and enterprise domain. These are linked by a fourth domain which consists of the intermediate or bridging organizations that support the flow of knowledge between the other domains. The final two domains incorporate infrastructure related elements (e.g. banking and business support systems) and the external environment which provides the enabling conditions and incentives for innovation.

A key feature of an innovation system is the interaction among a range of actors which can be from public and private sectors, and civil society organizations. The actual actors and their functions depend on the context, drivers, and goal of the innovation system. There may be different drivers of the innovation system. These have been divided into market and non-market drivers. An agricultural product value chain (APVC) is an example of a market driven innovation process where the actors interact through the market. However, a market driven innovation system may not necessarily have as its goal to benefit small-scale farmers or have a pro-poor impact. Kaplinsky and Morris argue that in the context of globalization and the disjuncture between market integration versus the extent to which people gain, value chain analysis can identify where up-grading may have the most pro-poor impact. (Kaplinsky and Morris, 2000) The Participatory Market Chain Approach (PMCA) (Bernet*, et al.*, 2006) is one pro-poor value chain approach which differentiates itself from other approaches by its focus on stimulating innovation and long term partnerships among farmers, market agents and service providers. In this way it emphasizes the importance of social capital formation. Hall et al. have also pointed out that the market alone is not sufficient to promote interactions for innovation and that the public sector and or intermediary organizations have a critical role to play (Hall*, et al.*, 2005a). Non-market drivers of innovation may include policy changes or incentives, access to information, finance, collective actions, and social demand in addition to availability of technology.

The World Bank has argued that an innovations systems approach and a value chain approach are complementary in that the innovation system perspective provides a way of planning how to create and apply new knowledge required for the development, adaptation, and future profitability of the value chain (World Bank, 2006). A value chain approach provides the context for analyzing opportunities for innovation; however it may focus more on market actors and the productive sector. If the value chain is conceptualized as the business and enterprise domain and part of a broader innovation system there can be linkages and knowledge flows through intermediaries to the other domains to influence macro economic factors, and the political economy. One implication for partnership research is to understand how a partnership is able to operate across different scales.

Devaux et al. have built on earlier work by Ostrom, Agrawal and the World Bank to propose a framework which integrates market chain and innovation systems concepts (Devaux*, et al.*, 2009). They propose an innovation arena which focuses on social processes of learning and the formation of social capital. The innovation arena is influenced by four sets of exogenous variables that influence the emergence and outcomes of collective action in market chain innovation. These are the external environment, biophysical and material characteristics of the market chain, characteristics of the market chain actors and institutional arrangements. The framework is reproduced below to illustrate these theoretical interactions. Horton et. al. have proposed to adapt this framework for assessing the performance of partnerships (Horton*, et al.*, in press).

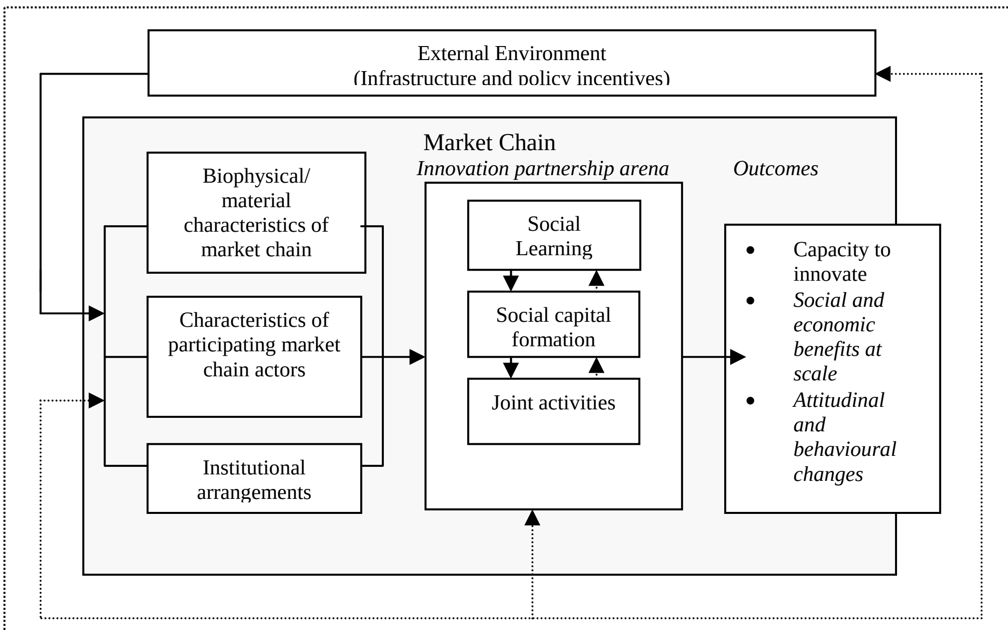

Figure 1. Framework for analyzing innovation partnerships. (Adapted from Devaux et al.)

A number of innovation systems characteristics can be analyzed to understand how partnership processes might work in support of specific socio-economic outcomes (Devaux*, et al.*, 2009; Spielman*, et al.*, 2009; World Bank, 2006). These characteristics are grouped as follows:

1. The patterns of interaction among partners based on their roles and the specific nature of the sub-sector that they are working in;
2. The social processes of learning which contribute to flows of information among partners, changes in attitudes and capacity for innovation;
3. The "framework conditions" or external environment that influences and is influenced by innovation processes;
4. The institutional arrangements for the innovation system to manage its internal and external interactions.

In the context of applying the framework to monitor the evolution and potential added value of innovation platforms as a partnership model, it is also proposed to refine it in the following ways: to emphasize the role of innovation *partnerships* and to show that the outcomes of the innovation process should demonstrate impacts related to *attitude and behaviour change; and up-scaling improved socio-economic outcomes.*

Therefore an innovation systems perspective can contribute to partnership research by providing an explicit theoretical framework as a basis to analyze the types of actors involved in a partnership, their interactions and the drivers or sources of the innovation process. This framework also emphasizes how a partnership in support of innovation processes needs to span different scales so that sub-sector value chain activities can be linked to the infrastructure, policy and institutional context for up-scaling.

What types of partnership practices instigate institutional changes conducive to creating a space for innovation?

Building on earlier work within the agricultural knowledge information systems (AKIS) framework, an innovation systems perspective brings in not only a greater heterogeneity of actors from beyond the public sector, but emphasizes the importance of interaction, potential synergies and knowledge exchange among those actors for innovation to take place (Röling, 2009). This highlights the importance of identifying mechanisms for knowledge management (i.e. the generation, capturing, codifying, sharing and utilisation of knowledge) to support social processes of learning and interaction as part of partnership practice.

As Hall has commented it is not clear the extent to which the interactions and social processes for learning are ad-hoc or require to be facilitated through a specific mechanism and learning tools (Hall*, et al.*, 2004). The potential practices and mechanisms depend on the level or levels that the partnership is working at, the type of partners and partners' organisational, social and cultural attitudes towards knowledge sharing and learning.

One approach that has been tried at a meso and national level is to establish "learning alliances" or "knowledge sharing platforms" to support out-scaling and up-scaling of innovations arising from project research (Fenta and Assefa, 2009). These generally have the aim of bringing together a range of stakeholders interested in innovation and the creation of new knowledge in an area of common interest. These types of mechanisms are particularly useful for linking into broader networks and when advocating for the policy and institutional changes required for further up-scaling of technologies. Another approach is to promote "communities of practice" which are groups of people who share a passion for something that they know how to do and who interact regularly to learn how to do it better (Wenger, 2002).

At the micro or local level Spielman et. al comment that a key constraint to effective innovation capacity among small-scale farmers is their inability to integrate and navigate within such knowledge and learning alliances or networks so that they are able to access technical and commercial information, markets and financing (Spielman*, et al.*, 2009). Tacit knowledge is held by farmers and in cultures with a rich oral tradition, face-to-face exchange remains central to formal and informal learning processes. The spread of cell phone use and application in the agriculture sector for dissemination of market prices shows that information and communication technology (ICT) technologies can spread quickly if appropriate, available and affordable. With increasing internet connectivity, Web 2.0 and social media tools also offer greater opportunity to tap into existing and emerging knowledge. Therefore partnership practice needs to find ways to bridge knowledge management processes across the micro-meso-macro levels as well as balance the increasing availability of ICT with social and institutional processes. Farmer Organizations (FOs) within a partnership may be well placed to develop this intermediary and facilitation role if ICT can be appropriately harnessed under low connectivity or limited bandwidth conditions to support their organizational and networking capacity. This would include FOs assessing and consolidating demands for knowledge and skills and negotiating appropriate bi-directional knowledge pathways with farmers.

What competencies and capacities are required for a partnership to contribute to innovation?

The previous sections have briefly examined how an innovation systems approach might contribute to a framework for research on partnerships. They have alluded to different types of capacities required, e.g. knowledge management. The specific technical knowledge and skills required will depend on the sector or commodity focus of the partnership. Knowledge and skills about market functioning and value chain analysis would be needed if a value chain approach is used. Down-stream, a focus on adaptive up-take of technologies, will require skills and experience around participatory approaches, collective action and extension methodologies. Capacities for up-stream activities will require advocacy skills for policy dialogue and for making linkages with those decision makers who can affect the policy and institutional change required for further up-scaling. With the greater range of actors from multiple sectors that the innovation systems approach encourages, these technical skills may be present or able to be drawn in. In addition, with an increase in the types of partners, disciplines and work across multiple levels, there will be high demand for leadership, coordination and facilitation expertise including negotiation, and conflict management and resolution skills (Hall, 2005b).

Working within a partnership involves transaction costs as time is invested in meetings to determine common objectives, and setting the agenda. This requires attitudinal changes at both the individual and partner organisation level, together with an element of risk-taking. As the partnership may be the institutional mechanism to support innovation there is also the need to monitor the partnership process itself through self-assessment and reflection in addition to monitoring progress towards intended outcomes. The coordination/ facilitation function may be taken up by one member within the partnership or lead partner. However, often in partnerships instigated by a research institution, while the technical and research skills may be present the "soft-skill" side is lacking. An additional implication for multi-stakeholder partnerships are the changes in administrative and financial systems and accountability mechanisms required to channel funds and manage reporting requirements. This may become more difficult when each partner has its own systems.

The use of an innovation systems framework within partnership development can help to identify what competencies are needed and how they can be strengthened. The framework can provide the basis to develop indicators to monitor how capacity is strengthened (Daane*, et al*., 2009; Spielman and Birner, 2008). These need to assess whether capacity for innovation is sustained beyond the original trigger for the partnership formation. It is also important to understand whether capacities at the individual level within a partnership can also influence the partner's own organisation to support new and more effective partnerships and capacities for innovation in other contexts.

How do the bio-physical characteristics of OFSP as a traded commodity in the market chain influence the type of partnership and institutional changes required to up-scale benefits to small-scale farmers

Innovation processes will reflect both the local socio-economic context and the characteristics of the targeted commodity. Therefore an understanding of the characteristics of orange-fleshed sweetpotato, together with consumer perceptions and preferences are necessary to identify opportunities for up-grading the value chain and the type of partnership needed to support innovation.

In many countries in East and Central Africa sweetpotato is considered as a subsistence, or "orphan" crop. It is predominantly grown by woman and rarely has priority in the crop planting cycle. Sweetpotato is often perceived as a substitute or "poor person's food" when preferred foods are not available or affordable (Andrade*, et al*., 2009).

The limited availability of quality virus free planting material at the beginning of the rainy season acts as a brake on increasing planted area and production. This can be attributed to the slow rate of vine reproduction, the perishable nature of the planting material, and difficulties of conserving planting material during the dry season or droughts. Therefore seed distribution mechanisms need to be decentralised and able to make available large amounts of material at key points in the seasonal cycle (e.g. at the beginning of the rains). One opportunity for innovation is mass tissue culture multiplication of disease free material in conjunction with decentralised multiplication and distribution sites. However for seed systems to be commercially viable there needs to be consistent market demand for sweetpotato so that farmers are confident that their investment in clean seed vine will bring commercial benefit.

There are some indications that consumer preferences for sweetpotato could be turned around as there is growing awareness of the nutritional properties of OFSP and the role of Vitamin A rich foods in a healthy diet. There are also examples of the potential for product differentiation and value addition at household, community and commercial scale. These include chipping and drying sweetpotato for milling into OFSP flour; use of OFSP flour in baked products such as bread, chapati, mandazi; use of fresh boiled and mashed OFSP for inclusion into baked products, juices; use in poultry feed (Uganda) and by food manufacturing companies (Rwanda) on a commercial scale (Thiele*, et al*., 2009).

The distance between production and markets or processing centres should be minimal given the perishable and bulky nature of the storage roots (i.e. maximum 7-10 days harvest to consumer). If there is scope for increasing the overall profitability of the OFSP value chain there may be opportunities for potential innovation and farmer organisation for establishing bulking points to reduce collection time, improving storage technologies to increase shelf-life and establishing effective communication mechanisms between producers, transporters, traders and processors (Rees*, et al*., 2003).

This discussion around the bio-physical characteristics of OFSP illustrates one set of the exogenous factors in the framework proposed by Devaux et al. There may be considerable potential to reduce transaction costs through market chain innovation by focusing on addressing the constraints related to availability of virus free planting materials, conservation of materials during dry periods and the perishable nature of the storage roots. It also points to the need to include and link certain actors along the value chain from the agriculture and health sectors. This would also help to ensure that growth in supply and demand is balanced for consistent market functioning.

Discussion

This brief review has provided a preliminary assessment of the contribution an innovation systems perspective could make to research on partnerships. Moving towards a practical application of an innovation systems approach we can place the OFSP market chain as a sub-system of the broader innovation system. Returning to the framework, we now need to identify the types of institutional arrangements, partnership practices and tools which can support both the interactions required along the market chain, and between the market chain and the broader innovation system which could support further up-scaling. This is discussed in the context of one model for the institutional arrangements for a partnership to support adaptive up-scaling of OFSP technologies – the innovation platform for technology adoption (IPTA).

An innovation platform has been defined as "a network of partners working on a common theme and using research knowledge in ways it has not been used before to generate goods and services that benefit the poor", (Research-into-Use, 2008). Within the DONATA project the IPTA was originally described as a platform comprising researchers, extension or advisory services, civil society organizations in agriculture i.e. farmer organizations, private sector or agri-business, NGOs, policy makers, etc. These would promote the dissemination of high impact agricultural technologies. The platform is described as an annual integrated programme for technology dissemination composed of community selected farmers within a given agro-ecological zone (African Development Fund, 2006). Although the language of an innovation systems approach is alluded to in its name, the theoretical basis for the platform was vague. In addition, the annual time frame was unrealistic and the additional capacities required for the platforms to move beyond a transfer of technology modality were not present. In practice the DONATA IPTAs are emerging in different configurations depending on local country and historical context. This provides an opportunity to use an action research approach to apply an explicit agricultural innovation systems framework in the evolution of the platforms. A number of tools could be tested for their appropriateness in this context. These include, but are not limited to: sub-sector analysis, stakeholder analysis, outcome mapping, and other qualitative tools to assess attitudinal and behaviour change related to partnership practices. The findings from these tools could then contribute to an assessment of the institutional, attitudinal, behavioural capacities and changes needed for the IPTAs to contribute to improved socio-economic outcomes. Therefore, using the framework adapted from Devaux et al. the following hypotheses could be refined and tested:

1. The institutional arrangements for the IPTA should include an explicit mechanism for knowledge management as an incentive for partners to work together on innovation processes.
2. Strengthening the knowledge management capacities of Farmer Organizations can provide a bridge for multi-directional knowledge flows within and across different levels of partnerships.
3. Social processes of learning and interaction among individual partners influence the partners' own organizational learning and institutional changes which could in turn create the more supportive partnership practices and up-scaling of innovations.
4. The IPTA is able to provide an interface for the sub-sector value chain at the local level but is also able to span the other levels necessary to support policy dialogue and influence for scaling up.

Conclusions

This paper has briefly reviewed the agricultural innovation system literature in order to understand how an agricultural innovation systems perspective can contribute to our research on partnerships. An innovation system perspective can contribute to refining definitions of partnerships by emphasizing the importance of multi-sectoral partnerships so that relevant actors fully participate in innovation processes that support the dissemination and use of research outputs. Recent literature has highlighted a number of innovation system characteristics relevant to partnership practice which can be tested to understand whether partnerships for innovation can add value to the adaptive uptake and up-scaling of research outputs. These demand the integration of multiple disciplines, the ability to span multiple levels and to negotiate multiple objectives across the research and development domain. However tested institutional mechanisms to manage these processes efficiently are still lacking.

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Participatory breeding experience and implications for sweetpotato breeding in Uganda

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ABSTRACT

The National Sweetpotato Program (NSP) breeding cycle in Uganda takes 7-8 years to officially release a variety. In 2003 participatory plant breeding (PPB) was initiated in six farmer groups (3 each in Central Uganda and Northern Tanzania) with the objective of assessing the benefits of PPB, including the time it would take to deliver improved varieties to farmers, and to take advantages of PPB. Segregating populations were given to each group to select superior sweetpotato clones. In 2005 trials in Tanzania, and Kiboga in Uganda were disrupted by monkey damage and drought, respectively. In Uganda, however, seven promising PPB advanced selections were made by 2006 and were evaluated by the NSP on-farm and on station in 4 locations (four replications per site). From the PPB results clones NKA1081L, NKA259L and NKA103M were as good as or better in performance than the local checks. Release documents for NKA1081L have been prepared and other PPB materials will be evaluated further to generate data on stability for official release. Farmers started consuming and selling PPB sweetpotato clones in the third to fourth year, which would occur in year six to seven in conventional breeding. These PPB trials demonstrate the potential for rapid progress in sweetpotato breeding in targeted environments, and the high risks involved in loosing valuable genetic material due factors such as drought and destruction by animals.

Keywords: breeding efficiency, botanical seed, clonal evaluation, variety ranking.

Introducion

Participatory plant breeding (PPB) involves farmers selecting genotypes from segregating populations or generations. Successful examples of PPB have been reported in the literature. For example, Sthapit *et al*. (1996) conducted PPB with farmers in Nepal to select chilling tolerant rice from F5 bulk families. Joshi and Witcombe (1996) created a broad-based maize composite for PPB in India, and the first selection by farmers was in Gujarat in the 1995 rainy season. PPB improved selection efficiency in barley (Mangione et al., 2006).

PPB facilitates close interaction among farmers, researchers and other actors in crop genetic improvement, allowing researchers to respond more closely to the needs and preferences of resource-poor farmers and their market clients (Cleveland et al., 2000). PPB also results in better identification of criteria that are important to the local community, targeted local environmental conditions and varieties obtained from this process are developed more rapidly, are more diverse and have higher adoption rates (Witcombe et al., 2003). Farmer selection of finished or near-finished varieties is termed participatory varietal selection (PVS), while farmer selection of segregating materials with a high degree of genetic variability is known as PPB (Witcombe et al., 1996). Ceccarelli et al., (2000) also described testing and selecting in the different locations representative of the target-breeding environment as decentralized breeding. The National Sweetpotato Program (NSP) breeding cycle in Uganda takes seven to eight years to officially release a variety. In 2003, the NSP and the Natural Resources Institute together with Ugandan and Tanzanian farmer groups initiated PPB trials (Gibson et al., 2008) with the objectives of: 1) estimating the time it would take to deliver improved varieties to farmers, and 2) assessing any other advantages of PPB.

materials and methods

Seedling Nurseries. Sweetpotato participatory breeding trials in Uganda were started in May 2003. Sweetpotato botanical seed was scarified in concentrated sulfuric acid at the National Crops Resources Research Institute (NaCRRI), Namulonge, washed under running water, and pre-germinated overnight on moist filter paper in covered petri plates. The pre-germinated botanical seeds (segregating populations) were given to farmer groups in the districts of Luwero, Mpigi, and Kiboga in Central Uganda, and three groups in Kyaka, Nyungwe and Maruku in the Lake Zone of Northern Tanzania to select superior sweetpotato clones. The pre-germination of the seed in Northern Tanzania was done at Maruku Research Station. The pre-germinated seeds were planted in one meter wide raised field seedbeds at a spacing of 10 cm by 20 cm. The seedlings were watered as required to allow establishment. Each group received 2,000-6,000 pre-germinated sweetpotato seed of at least two families (New Kawogo and Bunduguza) depending on the availability of scientific staff, technicians, and willingness of the groups to handle segregating populations in the seedling nursery and subsequent large numbers of clones in the initial stages of the PPB trials. Each selected seedling furnished 5 vine cuttings that were planted at each of the six sites on ridges 1 m apart, and 30 cm between the plants. Subsequent clonal selections were planted on mounds or ridges in 2004 onward. By 2005 onward the remaining selected clones were planted in three replications, minimum (Tables 1 and 2). In Kiboga, our research team retrieved (rescued) eight remaining sweetpotato clones that the farmers had abandoned in 2006 in the PPB trial due to severe drought. The 8 clones were planted and multiplied at Namulonge, and were taken back to Kiboga for evaluation by the farmers in October 2006. All the sweetpotato clones in Tanzania were lost due to drought. monkeys and hippopotamus damage between 2005-2006.

Clonal Evaluation. In 2006/2007 we evaluated in PPB trials the selected SP advanced clones in three districts:

(a) Luwero- Nine farmers hosted the trials. Each farm consisted of a household that planted 1-3 ridges (50 plants per ridge), 1 m between ridges, 30 cm between plants on the ridge, with Dimbuka and NASPOT 1 as check varieties. At harvest, five months after planting, taste ranking was done by 12 farmers (8 females, 4 males), where, 1 = best (most preferred); 8 = least preferred based on pair-wise selection of the 8 varieties.

(b) Mpigi- Fifteen farmers (farms) hosted the PPB trial (13 females, 2 males) who planted 4 ridges (30 plants per ridge), 1 m between ridges, 30 cm between plants on ridge. Taste ranking was done by 15 farmers (12 females, 3 males): 1 = best (most preferred); 8 = least preferred as described above.

(c) Kiboga- One farmer hosted the PPB trial. A group of nine farmers (8 females, 1 male) planted the trial at one farm in three replications, on mounds (3 plants per mound), 1 m between centers of mound. There were seven clones rescued from drought and two local checks. All the rescued clones performed poorly compared to the control, and so were discarded. However, the promising seven clones from Luwero and Mpigi were planted in 2007 in Kiboga to continue the PPB trials.

PPB trial evaluation on-station. The promising advanced clones in the PPB trials in Luwero and Mpigi were evaluated on station at Namulonge, Kachwekano, Ngetta and Serere in 2006-2009. The routine procedure for the NSP for evaluating advanced sweetpotato clones was followed. There were 4 ridges, 5.4 m long, 1 m between ridges, one vine cutting per planting point on the ridge, 0.3 m between plants (18 plants/ridge) (plant density 33,333 plants/ha), in a randomized complete block design (RCBD) with 4 replications. All outside rows of the experimental plots had border plants to minimize experimental error due to competition by border plants in adjacent plots. SPVD and *Alternaria bataticola* blight were scored at 2 months after planting, while vine, and total root and biomass yield were computed from plot yields. Dry matter content (DMC) of storage roots was expressed as the average percentage of dry weight of fresh weight. DMC was determined after weighing two replications of 500 g samples of sliced roots and oven- drying to a constant weight at 65^{o}C.

Results

The number of promising sweetpotato clones in PPB trials declined sharply each selection cycle from over 2,000 clones in 2003 to less than 10 by 2006 (Tables 1 and 2). Selection rates varied from 0% where there were problems of drought (Kiboga in Uganda and Kanyigo in Tanzania), and monkeys and hippos (Kyaka in Tanzania) to 1.8% at Maruku (Tables 1 and 2).

Table 1. Selection of sweetpotato clones (C) from seedlings (S) by farmers in sweetpotato participatory breeding trials in Central Uganda and Northern Tanzania, 2003-2007, showing C rescued from drought (RFD), and destroyed by monkeys (M) at single site (SS) or replicataions

Year	Central Uganda (District/Site)			Northern Tanzania			Number of sites
	Mpigi	Luwero	Kiboga	Kyaka	Nyungwe	Maruku	(Replications)
	Kitutuntu	Manyama	Watuba				
2003	6,000 S	6,000 S	6,000 S	2,000	2,000	2,000	1
	553 C	2,382 C	902 C	0 (M)	0 (D)		1 (1)
	117 C	163 C	126 C	0 (M)	0 (D)		1 (1)
2004	25 C	68 C	67 C	0	0	398	1 (1)
	21 C	14 C	67 C	0	0		1 (1)
2005	11 C	13 C	40 C	0	0	36	1 (3)
2006A	3 C	4 C	8 C (RFD)	0	0	0	1 (4)
2006B	7 C	7 C	8 C (SS)	0	0	0	10-15 (10-15 farms)
2007	7 C	7 C	7 C	0	0	0	10-15 (10-15 farms)
Selection (%) 2005	0.18	0.22	0.67	0	0	1.8	

Sweetpotato clones considered superior by the farmers and originally selected in Luwero in the PPB trials end with L in their clone name, and those originally selected in Mpigi end with M. These superior clones were exchanged at the third clonal generation (March 2005) evaluation stage. Results of the promising advanced clones in on-farm trials in Luwero and Mpigi are shown in Table 2. Clones NKA102M, NKA103M, NKA1081L, and NKA318L were selected in both districts, NKA259L was selected in Luwero but not in Mpigi. BND145L was selected in Mpigi but dropped in Luwero. The reasons for ranking high and selecting the clones were: attractive skin color (purple/red) and flesh, plenty of vines, high yielding, large straight storage roots, continuous storage root setting or yield, less susceptible to weevils, drought tolerant, mealy, and not fibrous (NKA1081L, NKA318L, NKA259L). The local control (Dimbuka) was out yielded by all the promising PPB selections by 23-84%, and was ranked among the last in acceptability in Mpigi in 2005 (Table2), clearly presenting considerable advantage in the PPB selections. In Mpigi, where SPVD pressure is high, Dimbuka was less resistant to SPVD than the PPB clonal selections. There was no significant yield advantage over the local check (Dimbuka) or the released variety (NASPOT 1), but NKA103M, NKA316M, and NKA259L were ranked better than the two former varieties in Luwero in 2005 (Table 2). The reasons for ranking clones low were in different combinations: not sweet at all, very hard, low yielding, susceptible to drought, low vine yield, very susceptible to weevils and diseases (NKA41M, BND145L, Dimbuka).

Results of the same promising PPB clones evaluated on station in four locations are shown in Table 3. From the on-farm (Tables 1-2) and on-station (Table 3) trial results, clones NKA1081L, NKA259L and NKA103M were as good or better in performance in NSP conventional trials for the desired traits than the local checks in specific locations and in the four agroeclogies represented by the four stations. The desired traits included marketable and total root, and biomass yields, resistance to Alternaria blight, SPVD and weevil (Tables 2 and 3).

Table 2. Summary of performance of promising clones in sweeptato participatory breeding trials on-farm, 2005-2007 (sweetpotato virus disease (SPVD) and other scored traits, rating scale = 1-5 (1 = no apparent damage, 5 = severe damage; taste ranking, 1 = first choice (best), 10 = last choice)

District/ year	Code	Clone	Yield (t/ha)		Disease severity		Taste
			Root	Biomass	SPVD	Alternaria	test rank
Mpigi 2005	1	NKA259L	18.0	37.3	3.0	2.0	5
	2	NKA103M	16.8	60.1	2.3	1.7	2
	3	NKA102M	19.5	54.5	3.0	2.0	8
	4	NKA41M	17.4	58.1	3.0	3.0	1
	5	WAG34L	13.9	63.7	2.3	2.0	7
	6	NKA1081L	27.8	77.3	2.3	2.0	3
	7	BND145M	3.8	13.3	3.0	5.0	4
	8	NKA318L	30.1	53.6	2.3	2.3	3
	9	Dimbuka	4.9	46.4	3.7	2.0	7
	10	BND145L	18.1	45.8	2.3	2.7	6
	11	NKA51M	5.7	17.9	2.7	2.0	4
	Mean		16.0	48.0	2.7	2.4	NA
	LSD (0.05)		13.5	32.5	0.8	0.7	NA
	CV (%)		49.5	39.8	17.4	17.9	NA
Luwero 2005	1	NKA259L	17.2	31.9	1.7	1.3	3
	2	NKA1081L	12.2	30.2	1.3	1.3	6
	3	NKA147M	11.9	21.8	1.3	1.3	7
	4	NKA318L	16.1	28.9	1.7	1.7	2
	5	NKA103M	10.7	24.7	1.3	1.0	5
	6	NKA102M	9.4	28.6	1.3	1.3	1
	7	BND145L	17.6	33.8	1.3	1.3	9
	8	Dimbuka	17.9	44.5	1.7	1.3	8
	9	NASPOT 1	16.7	32.2	1.3	2.0	4
	Mean		14.4	30.7	1.4	1.6	NA
	LSD (0.05)		6.3	10.0	0.8	1.3	NA
	CV (%)		25.4	18.8	33.6	47.3	NA
Soroti 2007	1	NKA259L	2.7	6.6	1.2	1.0	10
	2	NKA103M	3.8	7.8	1.0	1.0	3
	3	NKA1081L	3.7	7.2	1.0	1.0	1
	4	NKA318 L	2.9	6.7	1.2	1.2	8
	5	NASPOT 1	4.0	7.5	1.0	1.0	4
	6	Dimbuka	3.2	6.9	1.0	1.0	7
	7	BND12K	2.5	8.3	1.0	1.0	5
	8	NKA14K	2.5	5.5	1.0	1.0	9
	9	BND21K	1.4	5.0	1.0	1.2	2
	10	BND18K	2.5	6.9	1.0	1.0	6
	Mean		3.1	6.8	1.1	1.0	NA
	$LCD_{0.05}$		1.2	2.4	0.3	0.3	NA
	CV (%)		29.6	27.0	22.7	19.5	NA

Table 3. Performance of 10 sweetpotato clones selected in participatory breeding trials in four locations on station - Namulonge, Kachwekano, Ngetta and Serere, planted between June and October 2006 and harvested 5 – 5.5 months after planting (sweetpotato virus disease (SPVD) and other scored traits, rating scale = 1-5 (1 = no apparent damage, 5 = severe damage)

Code	Name of clone	Marketable root yield (t/ha)	Total root yield (t/ha)	Dry matter %	Vine yield (t/ha)	Biomass yield (t/ha)	SPVD	Altermaria	Weevil damage
1	NKA259L	34.7	36.2	33.6	23.5	59.7	1.8	1.6	2.3
2	NKA103M	32.4	32.9	32.8	22.0	54.9	1.5	1.2	2.3
3	NKA102M	28.7	30.1	32.3	22.2	52.2	1.6	1.8	2.3
4	NASPOT 1	38.0	39.2	32.8	31.7	70.9	1.5	2.1	2.1
5	Local check	16.1	17.1	33.3	46.8	63.9	1.5	1.6	1.9
6	NKA1081L	37.0	38.1	31.9	30.1	68.2	1.4	1.3	2.1
7	NKA318L	29.3	31.1	32.3	20.0	51.1	1.6	1.2	2.3
8	Dimbuka	25.8	27.3	32.6	25.2	52.2	1.6	1.4	2.3
9	BND145L	27.4	29.5	32.5	33.0	62.5	1.4	1.3	2.3
10	New Kawogo	24.6	25.6	30.9	30.8	56.5	1.8	1.9	2.2
Mean		29.4	30.7	32.5	28.5	59.2	1.6	1.5	2.2
$LSD_{0.05}$		6.8	7.7	NA	8.0	12.5	0.2	0.3	0.2
CV (%)		32.9	30.1	NA	39.9	30.1	21.8	28.9	15.0

Discussion

From the on-farm (Tables 1-2) and on-station (Table 3) trial results, clones NKA1081L, NKA259L and NKA103M were as good as or better in performance for the desired traits than the local checks in specific locations and in the four agroeclogies represented by the four stations. The taste ranking varied with location and community, suggesting that the clones could have specific adaptation. Among the PPB selections NKA1081L has been selected for official variety release based on its superior performance (Tables 2-3) (Mwanga et al. 2009). These PPB trials demonstrate the potential for significant rapid progress in sweetpotato breeding especially in specific target environments. In the third year (2005) of clonal selection, participating farmers had started consuming sweetpotato from the promising PPB materials in their homes. In the fourth year (2006) PPB participating farmers started selling NKA318L and NKA259L in their local markets in Zirobwe, Luwero District. This is a big plus for the PPB approach in ensuring cultivars cultivars identified are well adapted to specific conditions and are highly client-oriented. These results are in agreement with Gabriel et al. (2000), Thiele et al (2001), Witcombe et al. (2003), Ssemakula et al. (2003), Belay et al (2008), and Gibson et al. (2008). Sweetpotato consumption and exchange by participating farmers (PVS) in the so called conventional breeding would normally start only in year six or seven (Mwanga et al. 2001, 2003).

These PPB trials also demonstrate the high risks involved in loosing valuable genetic material due to such factors as drought, destruction by wild animals such as monkeys and hippos and domestic animals such as cattle and goats, thefts by neighbors, farmers abandoning PPB trials due to fatigue because of the long periods (several years) involved to be committed to conducting the trials, death of the most active participating farmer(s) in the group, inadequate budget support, and the type of starting (base) breeding populations. In all our participatory on-farm selection trials (not PPB) NSP always selects about 15 farmers to host the trials in each location in a district. In almost all cases we experience various combinations of the above-mentioned problems, and end up excluding 30-40% of selected farms from the analysis. In the PPB trials, it is important to keep apart a portion of the populations under evaluation to resort to should such problems crop up. In the on-going PPB trials, we started with very good, carefully selected populations, otherwise all the populations would have been wiped out in the first two to three seasons of planting because we were working in agroecologies where SPVD pressure was high.

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Genotype x environment interactions and participatory on-farm selection of sweet potato in the Northern highlands of Tanzania

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Abstract

Sweet potato genotype x environment (G x E) interactions, genotype response to environments, stability and participatory on-farm selection for fresh storage root yield were studied n the Northern highlands of Tanzania. Eight varieties were on-farm evaluated in a randomized complete block design whereby farmer's fields were treated as replicates at four locations. G x E interactions were analyzed using linear regression. Analysis of variance of total roots yield data showed significant mean square variation within varieties and environments *($p \leq 0.05$)*. Statistically significant varieties and environment interactions also occurred *($p \leq 0.05$)*. The pattern related mainly to the varietals response to differences in yield potential between environments and in varietals ability to yield at environment with poor yield potential. Local variety "Tengeru Red" and introduced one CIP 4400131 "Noveto" with respective slope values of 1.02 and 1.04, smaller standard error (s.e. = 0.09) values, relatively high total roots yield and a coefficient of determinations (R^2=0.98), could be considered the most widely adapted varieties. However, CIP 4400131 with negative intercept is not likely to perform better at poor environments. Considering farmers selection criterion used, all of the eight sweet potato varieties, were readily accepted by farmers.

Keywords: Adaptation; stability; sweet potato; genotype x environment interactions; on farm selection; Tanzania.

Introduction

Root and tuber crops particularly sweet potato (*Ipomoea batata,* Lam) is firmly established in the farming systems of Tanzania (Kapinga et *al.* 1995). In the Northern highlands of Tanzania, a future of subsistence production of sweet potato lies in the introduction and diversity of cultivars (Kuoko, 2004). The reasons for this include - (1)adoption for new improved high yielding varieties, (2) taste preference of the growers and consumers, (3) the need to produce sweet potato for human consumption and dairy cattle, and (4) apparent suitability of cultivar to specific environment i.e. genotype x environment interactions. In Tanzania, on-farm introduction and subsequent selection for sweet potato genotypes with high storage root yield will continue to be the priority objective of the National Root and Tuber Crops Research. In the 1990's the programme received diverse sweet potato varieties from the International Potato Centre (CIP), Sub Saharan. Only six promising varieties were selected for multilocational trials in the Northern highlands of Tanzania. The performance of the cultivars varied from location (environment) which suggested the presence of genotype x environment interaction. The G x E studies is of paramount importance in the specific environments in which the varieties are to be grown (Ortiz and Ilse de Cauwer, 1999). This is because sweet potatoes multilocational trials programmes generate phenotypic data for storage roots yield and other traits that enable us to obtain the most accurate estimates of variety performance that are possible, within the limitations imposed by time. Different attempts have been made to solve the challenges created by G x E interactions e.g. (Hanson *et al.* 1956; Comstock and Moll, 1963). Interest has been focused on the regression analysis. This technique was originally proposed by Yates and Cochran (1938) and later modified by Finlay and Wilkinson (1963); Eberhart and Russel (1966); Hildebrand and Russel (1996). In this technique we perform a linear regression between site average yield (environment index) and variety yield (treatment). The sweet potato varieties were then subjected to multilocational trials in diverse sweet potato growing areas of the Northern highlands of Tanzania. The objectives were – firstly to determine the nature of G x E interactions on the total roots yield (tones ha^{-1}); secondly to identify stable and adaptable varieties using different parameters; thirdly incorporate farmers selection criteria.

Material and methods

Experiment design. Eight varieties (Table 2): six selected from the introduced varieties by the CIP-Sub Sahara, and two local ones were evaluated between 2001 and 2003 cropping seasons at four locations of farming system zones of Northern Tanzania (Table 3). Farmers Research Groups involving 20 - 25 sweet potato growers in each district were involved in the trials. Each farmer was treated as a replicate and was given with 100 cuttings of each variety to plant and manage. The experiment was harvested after 135 – 145 days after planting during the long rainy season (February – July).

Data collection and analysis. Data collected were fresh storage roots yield, number of roots per plant, weevil infestation virus score and organoleptic taste using a standard method by NRI-National Root and Tuber Crops Improvement Programme. The analysis of variance was used using INSTAT (Reading University, UK) statistical package.

Farmer's assessments and selection. A pair wise method of ranking was used in collaboration with farmers to assess - plant vigor, appearance (root shape and color), and size. They also listed important selection criteria for best/poor variety. Data collected were not subjected to a statistical analysis using the

Stability analysis. The stability parameters suggested by Finlay and Wilkinson (1963), Eberhart and Russel (1966) and Hidelbrand and Russel (1996) were also calculated. This was done using data shown in Table 3. Four stability parameters were computed from individual linear regression between site mean yield (environment index) and variety mean yield: (1) *a* the intercept, (2) *b* value, slope or regression coefficient; (3) the mean square deviation from the regression of each variety (standard error s.e value) and (4) coefficient of determination (R^2 values) According to Eberhart and Russel (1966), for a variety to be considered stable, should meet criteria of high mean yields, slope equal to unity and standard error of the difference *s.e.* approaching zero. The slope measure the extent to which a variety responds to a unit difference in yield potential between sites. A steeper slope indicates greater response. Therefore, lower slope signify less variation in yield potential across sites. The intercept indicates the relative ability of the variety to yield at site with poor yield potential. Positive intercept mean that a particular variety is likely to perform better at poor site.

Results and discussion

Statistical analysis. The experiments were harvested at 135-145 days after planting. Statistical analyses over three years did not show any year x treatment interactions. Therefore, the data were combined across years and the results are discussed as means over the three years of study. Combined analysis of variance for total roots yield, weevil percentage, and virus score is shown in Table 1. The effects of varieties and site on mean total root yield were significant *($p \leq 0.05$)*. There was also significant mean squares interaction between environment and genotypes *($p \leq 0.05$)* as was expected. These results were similar to those obtained by Ngeve (1993) and Ndolo *et al.* (1995) who reported significant interactions between sweet potato varieties and environment. The variations in yield between sites were due to variations in soil, weather characters and agronomic management. Weevil infestations were also significant affected *($p \leq 0.05$)* by the variety.

Table 1. Combined analysis of variance

Source	df	Mean sum of squares		
		Total root yield	%weevil infestation	Virus score (1-5)
Variety	7	173.56**	414.96**	2.1
Site	3	174.4**	54.51	1.3
Year	2	8.82	42.13	2.2
Variety x site	33	18.19**	61.64	1.3
Variety x year	22	11.72	32.34	1.8
Site x year	6	20.62	77.96	1.4
CV%		30.8	46.8	13.2

Crop performance. Table 2 shows combined total root yield, number of roots per plant, percentage weevil infestations and virus scores. Mean yield was 12.4 tones ha^{-1}, and CIP 4400123, 4400131, and local check Tengeru Red recorded higher mean root yield. The high yielding varieties were due their elevated root size and not to number of roots per plant. In the Northern Tanzania, sweet potato is a food and cash crop. The crop is retailed in heaps and the average number of roots per plant and roots size distribution is important characters. Similarly for household consumption the crop is peace meal harvested, and as Ndolo *et al* (1995) mentioned that the presence of small roots at the time of harvest may indicate continued potential yield for production. Number of roots per plant was consistent with mean value of 4.8. CIP 440024 recorded 6.6 roots per plant. All varieties were susceptible to the sweet potato weevils (*Cylas ssp*) infestations. The percentage of roots infested was greater in CIP 420009 (26.5%) and lowest in CIP 4400131 (9%). This later is attributed to deep rooting characteristics of the 4400131. This may show that probably this variety is resistant or tolerant to sweet potato weevils. Table 3 shows total root yield across the sites. Yield across the sites varied from 6.3 tones ha^{-1} for CIP 4400105 to 24.0 tones ha^{-1} for CIP 4400123. The range was 9.4 tones ha^{-1} at Mwanga to 15.4 tones ha^{-1} at Arumeru. Tengeru Red, CIP 4400123 and CIP 4400131 consistently performed better in all sites. The highest yields were obtained in the Arumeru, because despite a good climate, farmers irrigate their sweet potato crop. Lower yield were recorded in Mwanga due to the prolonged drought and declining fertility. Virus was not a serious problem, as no significant mean square differences and interactions were observed; therefore, virus might not be attributed to the discrepancies in yield. Total roots yield data from Table 3 were used for stability analysis by environmental index.

Table 2. Combined crop performance in Northern highlands of Tanzania

Variety	Root yield tones ha^{1-}	# roots/plant	%weevil Infestations	Virus score (1-5)
CIP 4400123	17.3a[1]	5.0	24.2b	1.8
Tengeru Red	16.8a	4.2	18.4bc	1.8
CIP 4400131	15.4ab	5.7	9.0d	2.3
CIP 4400117	12.9b	4.5	21.4ab	1.6
CIP 440024	12.2b	6.6	23.1b	1.7
CIP 4400105	8.7c	4.8	18.3bc	2.0
CIP 420009	8.5c	3.6	26.5a	1.8
SPN/O	8.0c	4.1	17.5bc	1.8
Mean	12.4	4.8	19.8	1.8.

[1]Means followed by similar letters are not significantly at P=0.05 using LSD.

Table 3. Mean storage root yield of sweet potato varieties planted at four sites

Varieties	Arumeru	Mwanga	Lushoto	Mbulu
CIP 4400123	24.0	10.5	21.0	14.0
Tengeru Red	20.0	13.0	18.7	15.6
CIP 4400131	19.7	11.3	17.0	13.7
CIP 4400117	14.3	12.7	13.3	11.3
CIP 440024	16.3	8.7	13.5	10.0
CIP 4400105	9.6	6.3	11.0	8
CIP 420009	11.6	5.0	9.0	8.4
SPN/O	7.2	8.0	8.3	8.5
Site mean	15.4	9.4	14.0	11.2

Stability analysis. Table 4 shows summary of the parameters for individual fitted regressions. CIP's 4400105, CIP 4400117, SPN/O, and Tengeru Red had positive intercept, indicating that they are likely to perform better at site with poor yield potential. Slopes ranged from -0.04 for SPN/O to 2.01 for CIP 4400123. Four varieties CIP's 4400131, CIP 4400123, CIP 440024 and Tengeru Red had regression coefficients significantly greater than 1.0; they were sensitive to environment change. The goodness of the fit of the individual variety regressions i.e. R^2 value is an estimate of the stability of a variety's response to different sites. Then, SPN/O and to a lesser extent CIP 4400105 and 4400117 gave the least predictable performance i.e. lower R^2 values. In terms of a variety selection, an ideal variety would be one which was both responsive i.e. had high slope and gave some yield at low yield potential sites i.e. had a positive intercept. In this case Tengeru Red had a high slope (*b*=1.12), and positive intercept (*a*=2.769), standard error approaching zero (*s.e* 0.0958), high total yield (16.8 tones ha^{-1}) at R^2= 0.98 is the best variety and is likely to perform better even in poor sites. This shows that the local check is well adapted to this environment. CIP 4400131 despite having negative intercept (-1.153) is not likely to perform better at poor yield potential sites, but is a good variety to be promoted. This is because is tolerant to weevils, has high yield (15.4 tones ha^{-1}); standard error of the slope near zero (0.0983) and R^2=0.98. The yield trend might be explained as due to variety genetic potential, fertility, management and cool weather normally experienced in the Northern highlands during the vegetative stage of the sweet potato. Farmer plant their crop close the end of the rainy season i.e. April/May after finishing with other crops like maize and beans. This exposes the crop to unfavorable conditions like drought and cool temperature that might affect growth and development of the crop. Farmers seldom fertilize sweet potato.

Table 4. Stability parameters for total storage root yield

Variety	Yield	Intercept			Slopes			
		a	*s.e*	*t*	*b*	*s.e*	*t*	R^2
CIP 4400123	17.3	-7.154	3.054	3.17	2.01	0.2447	8.3	0.97
Tengeru Red	16.8	2.768	1.196	2.32	1.02	0.0958	11.7	0.98
CIP 4400131	15.4	-1.153	1.227	-0.94	1.04	0.0983	13.4	0.98
CIP 4400117	12.9	7.923	2.499	3.17	0.37	0.2002	1.8	0.63
CIP 440024	12.2	-3.462	2.391	-1.45	1.24	0.1916	6.5	0.95
CIP 420009	8.5	-1.154	2.107	-0.55	0.75	0.1688	4.4	0.90
CIP 4400105	8.7	0.693	3.587	0.19	0.63	0.2874	2.2	0.71
CIP 420009	8.5	-1.154	2.107	-0.55	0.75	0.1688	4.4	0.90
SPN/O	8.0	8.538	2.588	3.30	-0.04	0.2073	-0.21	0.02

Farmer assessment and selection. Table 5 shows selection criteria used by farmers in selecting sweet potato varieties. Yield and maturity were the most important characteristics as most farmers prefer high yielding and early maturing varieties. Ranking of varieties by farmers on basis of crop performance is shown in Tables 6.

Table 5. Farmer's criteria in selection of sweet potato varieties

Criterion	Arumeru	Mwanga	Lushoto	Mbulu
Size/shape	5	5	5	5
Yield	2	2	1	1
Maturity	3	4	2	3
Taste	6	3	3	2
Shape	4	6	7	6
Drought tolerance	7	1	4	4
Market	1	7	6	7

Table 6. Variety ranking based on crop performance

	Arumeru	Mwanga	Lushoto	Mbulu
CIP 4400117	3	7	7	6
CIP 4400131	7	6	6	8
CIP 420009	9	5	4	1
CIP 4400105	5	4	3	2
CIP 4400123	2	2	2	5
CIP 440024	6	1	1	7
SPN/O	8	8	8	3
Tengeru Red	1	3	5	4

Table 7. Ranking of variety on basis of crop performance – canopy/yield/taste

	Arumeru	Mwanga	Lushoto	Mbulu
CIP 4400117	3	1	7	3
CIP 4400131	4	2	6	6
CIP 420009	7	5	5	5
CIP 4400105	6	4	3	2
CIP 4400123	2	6	2	1
CIP 440024	5	7	1	7
SPN/O	8	8	8	8
Tengeru Red	1	3	4	4

Conclusion

Two genotypes, local variety "Tengeru Red" and CIP 4400131 "Noveto" could be considered the most widely adapted genotypes. However, CIP 4400131 with negative intercept is not likely to perform better at poor environments. Considering farmers selection criterion all eight sweet potato varieties, were readily accepted by farmers.

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The LatinPapa Network: a platform for pro-poor potato improvement and varietal dissemination

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Abstract

The LatinPapa Network seeks to enhance international collaboration between potato breeding programs in Latin America and pro-poor varietal dissemination at the national level with civil society partnerships involving private sector, development and base organizations. The initiative supports R&D activities in a total of 12 countries within the framework of the following working modules: 1. potato improvement, 2. varietal dissemination, 3. seed systems, 4. information platforms. The network aims to: 1. combine inputs and information from multiple disciplines, actors and environments to enhance current investments in potato improvement and dissemination, 2. match newly available resistant varieties with local ecologies, resource management options, production needs and markets, 3. systematize policies, processes, procedures and incentives for the uptake of new varieties, 4. exchange experiences in participatory varietal selection and seed systems toward 'scaling up' and adaptation to the regional context, 5. serve as an education, training and information resource in the areas of plant breeding and seed systems, 6. enhance access to and implementation of information technologies and communication strategies that contribute to potato improvement. This paper will present selected advances of the LatinPapa Network: international germplasm exchange, participatory varietal selection, marketing of potato varieties, production of pre-basic seed, adapted farmer seed systems, information & communication platforms.

Keywords: potato improvement, varietal dissemination, seed, information Systems.

Introduction

During the last decades the technical capacities of potato genetic improvement programs in Latin America have grown, resulting in average national yield increases in many countries. Despite success in selected environments, there is still a shortage of new diverse and robust potato varieties and efficient dissemination strategies that make products from genetic improvement available to poor smallholder farmers in marginal environments. On the other hand, the interinstitutional cooperation between and among countries, each with different Research & Development (R&D) demands and strengths, is essential to achieve impact through technological innovation (products & processes) in an increasing complexity context in Latin America: poverty pockets in the Andes and Central America, fast growing processing industries, increased presence of supermarkets, rapid urbanization, and climate change.

This context was discussed by representatives of the potato sector from 10 Latin American countries and finally key opportunities were prioritized during an international workshop held at the International Potato Center (CIP) in Lima, Peru, in September 2004. The lack of a regional platform which facilitates the exchange of experiences and promotes international interinstitutional collaboration was identified as a key need. Based on this concerted need, the Iberoamerican Innovation Network for Potato Improvement and Dissemination, in short the Latin Papa Network, was initiated. Partners and members include: national potato research programs (INIA's), universities, national and regional research and innovation networks, non-governmental organizations (NGO's), private sector (seed / industries) and base organizations (organized farmers / cooperatives). The initiative is supported by Spain's National Agricultural Research and Institute (INIA-Spain) and FONTAGRO (a regional agricultural development fund). At the moment the LatinPapa Network is integrated by eleven Latin American countries, including Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Ecuador, Panama, Peru, Uruguay and Venezuela, also furthermore by on Spain as the only EU member. The initiative was officially launched during the startup workshop, held between January 15 till 18, 2008, in Peru.

General objective

To co-develop and implement, together with Latin American national programs, an innovation platform for collaborative potato germplasm exchange and improvement, strategic and targeted dissemination of improved potato varieties, development of adapted and functional seed systems and technologies, in combination with adequate shared information and communication environments. All this with the final aim to ensure pro-poor smallholder access to technologies resulting in tangible improvements of either household food security or income (De Haan *et al.*, 2008).

Specific objectives

1. Combine inputs and information from multiple disciplines, actors and environments to enhance current investments in potato improvement and dissemination,
2. Match newly available resistant varieties with local ecologies, resource management options, production needs and markets,
3. Systematize policies, processes, procedures and incentives for the uptake of new varieties,
4. Exchange experiences in participatory varietal selection and seed systems toward 'scaling up' and adaptation to the regional context,
5. Serve as an education, training and information resource in the areas of plant breeding and seed systems,
6. Enhance access to and implementation of information technologies and communication strategies that contribute to potato improvement.

Methodology

The LatinPapa Network foments interinstitutional, horizontal and interdisciplinary collaboration between and among potato Research & Development (R&D) institutions (Bastos *et al.*, 2008). Interventions and project activities are framed around 4 working modules (strategic components):

1. 1. Germplasm exchange, documentation and evaluation. This module seeks that network members have greater access to pre-breeding material (novel sources of resistance), advanced potato germplasm (clones), standard procedures for evaluation (protocols), and breeding expertise (knowledge, peer to peer recommendation).
2. 2. Efficient dissemination of new robust varieties. This module aims to achieve accelerated, targeted and pro-poor release and diffusion of new varieties toward early adoption. Promotion and dissemination strategies include marketing tools (catalogues), demonstration trials, PPP initiatives, linkage of varieties to smallholder organizations, media (radio), among others.
3. 3. Operative and adapted seed systems. This module seeks to share adapted technologies for the production of pre-basic and basic seed among network members (e.g. aeroponics). At the same time it seeks to link seed production technologies to functional formal (Southern Cone) and farmer seed systems (Andean Region). Training is an important aspect of this module.
4. 4. Shared information, institutional learning and operational sustainability. This module proposes that network members, strategic partners and value chains members co-develop and use shared information and communication systems.

The overarching methodological focus of the LatinPapa Network includes the innovation system and value chain paradigms. The innovation systems approach recognizes that sharing technologies and information between and among people, organizations and institutions is essential to an innovation process. In addition that active interaction and collaboration among members of the R&D community is required to turn an idea into a process, product or market with the potential to effectively benefits poor farmers. Indeed, the outreach of an innovation depends on a complex set of relationships between actors who produce, distribute and apply knowledge. Therefore, the value chain approach is another important paradigm as it ideally seeks integration and collaboration between those organizations that develop, promote and utilize pro-poor technologies.

Organization

The LatinPapa Network has an international coordinator and elected steering committee. Together they are responsible for the general organization and management of the network, in addition to donor relationships. Additionally, in each country has a focal point for the national network. LatinPapa also has five working groups integrated by international experts in the themes addressed: germplasm, dissemination, seed, information and learning, regulatory framework and political incidence.

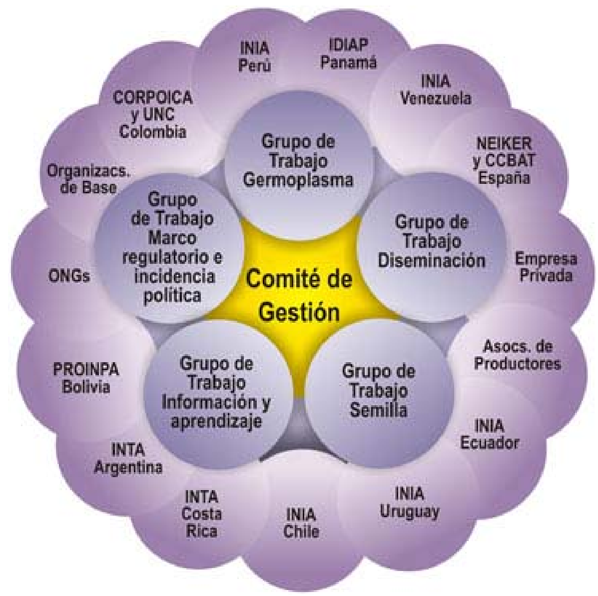

Figure 1. Organization of the overall management of the LatinPapa network (in Spanish)

Network members

International members of the LatinPapa network include the International Potato Center (CIP), McCain foods and *Cambio Alianza Andina*. National members include governmental research institutes and universities such as INTA-Argentina, INIA-Chile, PROINPA-Bolivia, INIA-Uruguay, INIA-Peru, INIAP-Ecuador, EMBRAPA-Brazil, CORPOICA-Colombia, UNC-Colombia, INIA-Venezuela, IDIAP-Panama, INTA-Costa Rica, CCBAT-España and NEIKER-España. More information about each of these institutions can be found on the LatinPapa website: http://www.cipotato.org/redlatinpapa/. In several countries active links with farmer cooperatives and base organizations have been established, e.g. with CONPAPA in Ecuador (http://www.conpapa.com/), COPABOY in Colombia, and ABBA in Brazil (http://www.abbabatatabrasileira.com.br/).

Many of the national coordinating institutions have actively promoted the formation of national innovation networks, e.g. *Consorcio Papa Chile* (Chile), *Red Patata* (Spain), and the *Mesa de la Papa* (Costa Rica). The LatinPapa network is financially supported by the INIA-Spain (http://www.inia.es/), FONTAGRO (http://www.fontagro.org/), STC-Peru, and the Generation Challenge Program (http://www.generationcp.org/).

Figure 2. Some of the international and national member institutions of the LatinPapa network

Selected advances

To facilitate monitoring, a yearly operative plan (AOP) is developed during the annual meetings of the LatinPapa Network. During the implementation phase of the first annual operative plan (AOP 2008), network members prioritized a total of 41 multilateral and 117 national activities. Each activity is detailed in an activity plan and most of those foreseen in the AOP 2008 have already finished while a few are still in process. The AOP 2009 also consists of well over 100 individual activities and accompanying plans. Activities are varied and range from pre-breeding to the dissemination of new varieties. Below, selected advances are summarized:

Module 1 (germplasm)

- Distribution of 837 genotypes from CIP to LatinPapa Network members, including advanced clones with late blight (Phytophthora infestans*) and virus resistance, heat and drought tolerance, and true seed families. These materials are currently used for national selection and/or as parental materials.*
- Advanced clones generated in national crop improvement programs have shared between Chile, Costa Rica, Spain, Uruguay and some other countries.
- At CIP, pre-breeding research on new sources of Phytophthora infestans resistance, including several species belonging to the Piurana clade, is being conducted. Interspecific hybrids are being characterized for resistance and agronomic performance.
- Crossing barriers, specifically self-incompatibility in diploid native potatoes (S. phureja, S. stenotomum, S. goniocalyx) and wild diploid (S. chiquidenum, S. paucissectum) and inter-specific pollen rejection from these species, are researched.
- Genotype by environment (GxE) interactions and stability for the yield and quality of 20 advanced CIP clones with resistance to virus (PVY / PVX) and late blight is investigated in contrasting environments in Peru. Additionally, a regional platform for GxE performance prediction with the use of GIS has been initiated using common sets of materials.
- An online training series for virus resistance screening has been developed. It can be accessed through: http://research.cip.cgiar.org/confluence/display/redlatinpapa/Videos.
- Special efforts are made to reach pockets of poverty marginal and isolated areas. Participatory Varietal Selection (PVS) is actively promoted and implemented by LatinPapa Network partners in Costa Rica, Colombia, Ecuador, Peru, Bolivia and Argentina.
- Together with Alianza Cambio Andina the M&B-trial design for Participatory Varietal Selection (PVS) is being consolidated with 5 R&D consortiums in Peru and 2 consortiums in Colombia. Decentralized clonal selection through these consortiums involves farmer communities, municipalities, NGO´s, farmer cooperatives, among others.
- The International Cooperators Guide (ICG; Bonierbale et al., 2007) has been updated and translated to Spanish. Publication is foreseen for 2009. In the meanwhile the LatinPapa website has a special section on protocols where manual can be downloaded.
- A series of regional training events concerning techniques and procedures have been organized, including a workshop about GxE analysis in Argentina, a sensory evaluation and cytogenetics workshop in Peru, among others.

Module 2 (dissemination)

- An online catalogue of advanced CIP clones has been designed and published on the LatinPapa webpage. Annually an updated catalogue in also distributed on CD-rom. See: https://research.cip.cgiar.org/redlatinpapa/pages/home.php?lg=en. Currently network members in Ecuador and Colombia are developing catalogues of advanced clones from their breeding programs.
- Some national programs have published variety catalogues of. For example, EMBRAPA-Brazil. INIA-Peru is close to publishing a commercial variety catalogue with 12 of their most recent varieties. A catalogue

of CIP varieties has also been developed. **http://www.cpact.embrapa.br/publicacoes/download/documentos/documento_247.pdf**

- Demonstration trials with new varieties have been implemented by several network members. These demonstration trials are generally installed at highly visible and frequently visited sites.
- Public Private Partnership initiatives as a way to disseminate new potato varieties are being implemented in several countries, e.g. in Peru between INIA and *Plaza Vea* supermarkets, in Costa Rica between INTA and Walmart supermarkets, and in Colombia between CORPOICA and McCain (see: Villamil *et al.*, 2008). Similar initiatives with development organizations also implemented, particularly in the Andean region.
- Another strategy used by some LatinPapa Network members, e.g. PROINPA Bolivia, is to promote new varieties at popular events: fairs, conferences and field trips.
- Under the section "documents of interest" the LatinPapa webpage offers some systematized experiences of dissemination from member institutions.

Module 3 (seed)

- The LatinPapa Network actively promotes aeroponics as an appropriate technology for pre-basic seed production. Production modules have been installed by INIA-Peru, INIAP-Ecuador and INTA-Argentina.
- The LatinPapa Network, recognizing that aeroponic seed production technology still needs to be fine-tuned, also promotes research on the production system. For example, a trial concerning the response of mini-tuber production of 10 clones under aeroponic systems in greenhouses in 2 contrasting environments in Peru started in early 2008 and is still ongoing. It is expected to reveal valuable insights into GxE interactions.
- An economic validation of different pre-basic seed production technologies is conducted comparing CIP´s aeroponics system, conventional peat-pot multiplication, CORPOICA´s and EMBRAPA´s hydroponics systems.
- A database with national seed laws from member countries has been published on the LatinPapa webpage. It also includes lists of seed providers of new varieties in each country. The aim is to have a single reference site with access to regional legislation so that comparisons can easily be made to stimulate adaptation towards functional seed laws. See: http://research.cip.cgiar.org/confluence/display/redlatinpapa/Semilleristas1
- The LatinPapa Network also actively aims to strengthen and diffuse adapted functional farmer seed system such as the system of internal control implemented by CONPAPA in Ecuador. A diffused-light seed storage system was implemented in Ecuador to strengthen the competitiveness of the farmer association. INIA is currently involved in stimulating replication of the successful Ecuadorian experience in Peru.
- EMBRAPA-Brazil published a video on pre-basic seed production systems with hydroponics.
- INTA-Argentina shared the experience of Autotrophic Hydroponics System with Chile, Bolivia, Ecuador, Colombia, Venezuela and Uruguay.
- INIAP Ecuador is validating the use of growth-stimulating microorganisms in aeroponics.

Module 4 (Information Systems)

A website of the Latinpapa Network has been designed and is continuously updated. See: http://www.cipotato.org/redlatinpapa/

Twice a year the InnovaPapa Bulletin is published. It informs about novel experiences and collaborative activities of LatinPapa Network members.

See: http://research.cip.cgiar.org/confluence/display/redlatinpapa/Boletin

- An information section with national variety release procedures has been included within the LatinPapa webpage. This allows network members to compare legal frameworks with the idea to make new variety release legislation more agile and less bureaucratic.
- Some of the national networks have also implemented their websites, e.g. the Red Patata: www.neiker.net/neiker/papata
- A common data platform for the future prediction of genotype by environmental adaptation is currently being developed by Latinpapa Network members. The initiative followed from the workshop "Stability Analysis and Interpretation of Results using AMMI, SREG and PLS and Diva-GIS".

Conclusions

The LatinPapa Network integrates potato breeders from National Agricultural Research Institutes (NARI), universities, private institutions and base organizations from 11 Latin American countries and Spain with the common objective to enhance the pro-poor impact of potato breeding through collaborative research on advanced potato germplasm, strategies for dissemination, seed systems and information management. The initiative formally started in early 2008 and has since actively promoted collaboration among its members.

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Farmers' empowerment on potato disease management through participatory research in Nepal

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Abstract

Participatory research on management of potato diseases particularly on late blight (*Phytophthora infestans*), wart (*Synchytrium endobioticum)* and black scurf *(Rhizoctonia solani)* were conducted in Nepal at different agro climatic conditions during 2003-2008. Potato clones CIP-384321.15, CIP-391058.35, CIP-392657.8 and LBr-40, PR-15860.8, PR-85861.12 and PR-15861.16 were found resistant to late blight under natural epiphytotic conditions of Chitwan (260 masl). Among the selected late blight resistant clones PR-85861.12 was most preferred by the farmers for its yield and tuber skin colour. Potato clones CIP-394005.115, CIP-393674.72B and some NPRP crosses, PR-15861.6, PR-25861.10, PR-25861.14, PR-35861.13, PR-35861.12 were found resistant to wart under naturally wart infested soil conditions at Nigale (2450 masl). Despite of having wart resistant character, farmers were reluctant to adopt these clones because of lower tuber yield than the existing cultivar 'Rosita'. Different management options were tested against black scurf disease, among them seed tuber treatment with 2% boric acid was found to be economical with highest disease control (41.7%) followed by seed and soil treatment with antagonist *Trichoderma harzianum* (30%). These options were accepted by the participating farmers of Bardiya (350 masl). Participatory research have enhanced the technology adoption process with respect to late blight and wart resistant clone selection and adoption of best black scurf management option as per their socio-economic conditions.

Keywords: black scurf, boric acid, late blight, participatory, *trichoderma*, wart.

Introduction

Late blight (*Phytophthora infestans* Mont de Bary), Bacterial wilt (*Ralstonia solanacearum*), Wart (*Sinchytrium endobioticum* (Schilb) Perc), Black scurf (*Rhizoctonia solani*) are the economically important potato diseases causing substantial yield losses in Nepal. Due to the individual disease yield loss ranges 15-40% depending on potato varieties grown and the conduciveness of weather prevailing at a particular location (NPRP 2005).

In high hills above 2000 masl late blight disease occur every year with the significant yield losses whereas, in the palin disease epidemic usually occurs after 2-3 years. The monitory loss estimated at the National level reaches beyond 72.5 million USD based on only 15% loss of production of 2008. Potato growers of Kathmandu valley itself spray fungicides from 11 to 15 times, which leads to increase cost of production (Sharma et al., 2007). The disease can be controlled considerably using resistant varieties, cultural practices and fungicides. The level of late blight resistances in presently available potato varieties is only intermediate and access of resistant varieties to the farmers is often limited and fungicides are too costly for resource poor farmers of Nepal.

Wart is second most serious disease of potato particularly in the cooler region (>2000 masl) of the country. The most favorable conditions for its development are warm temperatures (but not over 20°C) with enough humidity. Winter sporangia can remain viable for more than 40 years (Stuart et al., 2008). This disease is of quarantine significance due to the production of persistent resting spores and lack of effective chemical control measures (Putnam and Sindermann,1994; Hehl et al., 1998). Use of resistant varieties is only the most practical way of managing this disease. However, disease could be managed to some extent by soil treatment with fungicides and long crop rotation. In high hills long crop rotation is not accepted by the farmers because other crop's productivity is very low that can not cope with food deficit in the hills. Previously recommended all potato varieties are resistant to wart but farmers from wart infected areas are reluctant to accept these management options. Existing potato cultivar 'Rosita' is highly susceptible to wart and because of its severity productivity is decreasing (NPRP, 2007). Therefore there is high demand of high yielding, red skinned and resistant to late blight and wart disease.

In mid western region of Nepal espacially plain area , yield losses due to black scurf disease has been estimated ranging 5-60 percent depending on the prevailing weather during the crop period and crop rotation followed (Sharma and Khatri. 2004). Some recommendations have been made for disease control through seed tuber treatment with Sodium hypo-chloride (NaOCl). The seed treatment with mixture of Acetic acid 1% + Zinc sulphate 0.05 % solution for 15 min dip gave 100% kill of sclerotia (Dutta and Gupta 1982; NPRP, 1994). Seed tuber treatment with 3% boric acid solution dip for 30 minutes prior to planting to control black scurf disease of potato has been recommended (NPRP, 1994). Black scurf could be controlled by adopting appropriate crop husbandry i.e. planting vigorous sprouted seed, avoiding deep planting and avoid planting into cold and wet soil (Hawthorne,1997).

Farmers are eager to learn new options and seek solutions to their problems, but in many cases they lack know-how or access to them. Over the last 35 years, and particularly since the early 1990s, interest in participatory crop research and improvement has grown in recognition of its potential contribution to marginal areas with low agricultural potential (Hellin et al., 2006). There is a need to identify varieties and technologies that are suited to a multitude of environments and farmer preferences.

The participatory process involves narrowing the gap between research organizations and farmers' realities by ensuring direct farmer involvement at different stages of the research process. Taking these points in view, participatory research was performed on three major potato diseases i.e late blight, wart and black scurf, at their respective climate and socio economic conditions.

Materials and methods

Participatory experiments were conducted in three major potato growing locations representing high hills, inner terai and mid western terai of the country as per potato disease problems faced by the farmers.

For potato clone selection against late blight, **f**ifty seven potato clones received from the International Potato Center (CIP) and other sources were screened against late blight disease under farmers field at Sharadanagar, Chitwan (270 masl) inner terai during 2007/08. Ten tubers of each potato clones were planted in augmented design (Scott and Milliken, 1993) with a spacing of 25 x 60 cm in 2.5 m long rows under natural epiphytotic conditions. Tubers apparently healthy and in the same physiological conditions were planted in the fields during 3rd week of November to align with local cropping systems. Kufri Sinduri was used as late blight susceptible check variety, which was planted after each 9 rows of test clones and in the border around the trial to increase pathogens inoculums pressure. Prior to planting, fertilizer 150:100:60 kg N, P_2O_5, K_2O/ha respectively, along with 10 t/ha farm yard manure were applied as a basal dose. Cultural operations and irrigation was applied as per participating farmers' decision. Fungicides were not applied against late blight throughout the crop period. Experiment was conducted under natural late blight infected conditions.

Disease severity was scored on 1-9 CIP rating scale (Henfling, 1987). Where 1 indicates no disease infection and 9 indicates 100% foliage damaged by the disease. Disease was scored three times at 60, 70 and 80 days after planting (DAP). The disease score of 70 DAP was used for comparing the disease reaction of the potato clones. Test clones were categorized into five groups based on 1-9 disease rating scale as follows.

Range of score	Reaction category
<=1	HR (Highly resistant)
>1 to <=2	R (Resistant)
>2 to <=4	MR (Moderately resistant)
>4 to <=6	S (Susceptible)
>6 to <=9	HS (Highly susceptible)

Farmers in association with researchers scored the disease first at 60 Days after planting (DAP) then farmers themselves scored disease on succeeding observations.

For potato clone selection against wart, experiment was conducted on highly wart-infested soil, identified during the previous crop harvesting time. Forty five clones were tested and compared with wart susceptible check variety 'Rosita'. Sources of test genotypes were International Potato Center (CIP) and National Potato Research Programme (NPRP). Experiment was planted at the farmer's field at Nigale Sindhupalchok during first fortnight of February 2008.

Susceptible check variety was planted after each 9 test entries and was made its borderline. Experiment was in rod-row augmented design (Scott and Milliken.1993; Burgueno Ferreira et al., 2005) susceptible check was repeated 5 to 6 times depending on the number of test clones. Plot size was with row length of 2.5m long and 0.6 m width and planted in a spacing of 25cm X 60cm. Field was prepared as furrow and ridges with a spacing of 60cm. Compost @ 10 t/ha and fertilizer @ 150:100:60 Kg N, P_2O_5 and K_2O/ha were applied as basal. Intercultural operations were followed as per the farmers' practice. Fungicides were not applied throughout the crop period. Wart incidence was recorded at the time of harvesting based on the number of infected symptomatic tubers and apparently healthy tubers produced per 1.5 m^2 plots.

For Black scurf management at Bardiya, a heavily infested farmers field with *Rhizoctonia solani* was selected prior to experimentation at Mainapokhar, Bardiya. Treatments were fixed on consultation with participant farmers. Experiment was laid out in randomized complete block design (RCBD) with seven treatments and three replications. Black scurf infected seed tubers of variety 'Cardinal' were used in this experiment. Experiment was planted on second week of November in all the experimental years (2003-2005). Plot size maintained was 2.4m x 3.0m. Sprouted seed tubers were planted in 25 cm x 60 cm spacing at a normal depth. Recommended manures and fertilizers were applied@ 10 t/ha and 150:100:60 kg N, P_2O_5 and K_2O Kg/ha respectively were applied. Nitrogen was applied as three split doses. Half amount of Nitrogen, was applied at planting as basal and remaining half was applied during two intercultural operations as split doses. As per the treatments, soil was sterilized with Formaldehyde 1.0 % ai concentration through commercial Formalin 39%. *Trichoderma harzianum* in the form of NIPROT (Manufactured by Bio-Control Research Laboratories, Bangalore, India) was applied as seed and soil treatment and drenching after the emergence. As per manufacture's instructions *Trichoderma* was multiplied in well-decomposed FYM @ 10 g NIPROT/Kg FYM. Commercial brand of *Trichoderma* 'NIPROT' was well mixed in FYM and kept for 10 days under polyethylene cover to maintain the conducive temperature. Seed tubers were treated with boric acid of two concentrations (2% and 3%) prior to panting.

Crop was harvested at 105 days after planting and total yield per plot was recorded at harvest. Finally, disease severity was recorded on percentage comparing the corresponding pictorial severity scale developed and severity index was computed as reported by Tanil et al. 1982.

Results and discussion

Potato clone selection against late blight

Out of fifty seven potato clones screened under participatory late blight disease screening trial at Sharadanagar Chitwan, clones LBr-40 and CIP 384321.15 were found highly resistant and CIP clones 391058.35, 391617.54, 392270.32, 392271.58, 392657.8, 392661.18, 393280.57, 393280.64, 393385.39, 396233.38, 800982 were moderately resistant and rest of the clones showed susceptible to highly susceptible reaction (Table). Observation on late blight disease severity showed that environment of experimental site was found to be the most conducive for late blight development.

Highest tuber yield (33.30 t/ha) was obtained from the clones LBr-40 followed by 391616.54 (32.0 t/ha), 392657.8 (25.23 t/ha) and 391058.35 (24.60 t/ha) along with resistant reaction to the disease (Table1).

NPRP crossed potato clones PR 15861.8 and PR 15861.16 were found highly resistant with the considerable tuber yield 19.67 t/ha and 13.47 t/ha respectively. Eight clones showed resistant reaction to late blight with the significantly higher tuber yield ranging 16.33 to 26.6 t/ha. Participating farmers highly preferred PR 85861.12 because of its highest yield (26.6 t/ha) and tuber skin colour with moderate level of resistance against blight. Obtained yields were almost 3 to 4 times higher than susceptible check cultivars Cardinal and Desiree (Table 2). Participating farmers had expressed their satisfaction by getting late blight resistant potato clones with the desirable tuber yield without spraying any fungicides. Farmers have decided to multiply resistant clones and popularize them further in the community.

Table 1. Performance of potato clones showing moderately to highly resistant reaction to late blight under Chitwan valley conditions in 2007/08

Potato clones	LB score (1-9 scale)	Over all reaction to LB	Tuber yield (t/ha)
CIP 384321.15	1	HR	16.19
CIP 391058.35	2	R	24.60
CIP 391616.54	2	R	32.00
CIP 392270.32	2	R	23.70
CIP 392271.58	3	MR	19.05
CIP 392637.10	2	R	24.00
CIP 392657.8	2	R	25.23
CIP 393280.57	2	R	21.48
CIP 393385.39	4	MR	23.68
CIP 396010.42	3	MR	18.00
CIP 800982	2	R	12.50
LBr-40	1	HR	33.30
CIP 392227.15	4	MR	15.56
Kufri Sindhuri (Check)	9	HS	6.40
Total no. of test clones = 57			

LB score 1 = no disease; 2 = < 5%; 3 = 5 to <15%; 4 =15 to <35%; 5 =35 to <65%; 6 = 65to<85%; 7 =85 to <95%; 8 = 95 to <100 % and 9 = 100% damage
Reaction: HR (<=1); R (>1 to <=2); MR (>2 to <=4); S (>4 to <=6); HS (>6 to <=9)

Table 2. Farmers' participatory selection of National Programme bred potato clones at Sharadanagar in 2007

Clones	LB score	Reaction	tuber yield t/ha	Tuber colour
PR 15860.8	2	R	19.67	W
PR 15861.35	3	MR	20.33	W
PR 35861.24	3	MR	16.33	R
PR 225861.7	3	MR	19.53	W
PR 85861.9	7	HS	4.67	W
PR 85861.12	3	MR	26.60	R
PR 255861.2	3	MR	22.47	W
PR 255861.1	3	MR	20.47	W
PR 85861.8	3	MR	22.33	R
PR 15861.16	2	R	13.47	R
PR 85861.11	3	MR	22.33	W
PR 15861.1	9	HS	3.33	W
Resistant check (LBr-44)	1	HR	19.87	W
Susceptible check (Desiree)	9	HS	6.67	R
Susceptible check (Cardinal)	9	HS	7.33	R
Susceptible check (K. Sindhuri)	9	HS	8.20	R

LB score 1= no disease; 2= < 5%; 3= 5 to <15%; 4=15 to <35%; 5=35 to <65%; 6= 65to<75%; 7=75 to 85; 8=85 to <95%; and 9= 100% damage
Reaction: HR (<=1); R (>1 to <=2); MR (>2 to <=4); S (>4 to <=6); HS (>6 to <=9); Tuber colour R= Red; W=White

Potato clone selection against wart

Out of 45, sixteen potato clones namely CIP-378711.7, CIP-383178.22, CIP-384329.21, CIP-392228.66, CIP-392243.17, CIP-392243.52, CIP-392661.18, CIP-394005.115, CIP-93574.72B, CIP-394038.105, CIP-390682.7, CIP-392270.32, Panauti, Kufri Giriraj, CIP-388764.26, CIP-392206.35 were found resistant to wart under field natural infested conditions (Table 3). It was observed that, potato clones showing susceptibility to wart produced comparatively better tuber yield than the wart resistant clones. The reason could be that new exotic clones were not suitable for that climatic condition.

Widely adopted cultivar 'Rosita' produced highest tuber yield along with wart-infected tubers (23.4/ha) followed by LBr-40 (20.7t/ha) and 384321.15 (16.7t/ha), but found to be susceptible to wart. Warty tubers reduce the market price. Since, wart incidence was recorded to 64% in Rosita. Farmers will have to face extensive economic losses in the future. LBr-40 and CIP-384321.15, wart susceptible clones showed better performance in Chitwan and farmers had preferred for their high yield and late blight resistance. There was no wart disease problem in warm climate below 1000 masl.

NPRP crosses PR 15861.6, PR 25861.10, PR 85861.14 PR 35861.13 and PR 35861.12 showed resistant to wart under field conditions (Figure 1). In addition to previously released potato varieties three new potato genotypes PR 25861.10 and PR 85861.14 were found to be resistant to wart with considerable tuber yield ranging 15 to 21 t/ha. Participating farmers were positive to those clones and selected for further evaluation. Other resistant clones, produced very low tuber yields, were not acceptable to the farmers.

Table 3. Performance of potato clones against wart at Nigale during 2007/08

Acc no.	Infected tubers (No.)	Healthy tubers (No.)	Wart incidence %	Tuber yield (Kg/1.5 m^2)	Tuber yield (t/ha)
378711.7	0	50	0.0	1.2	8.0
383178.22	0	38	0.0	1.0	6.7
384321.15	6	73	7.6	2.5	16.7
384329.21	0	22	0.0	0.6	4.0
392228.66	0	54	0.0	0.7	4.7
392243.17	0	10	0.0	0.4	2.7
392243.52	0	36	0.0	1.5	10.0
392657.8	2	11	15.4	1.85	12.3
392661.18	0	51	0.0	1.9	12.7
393077.54	5	39	11.4	2.5	16.7
393385.39	11	55	16.7	2.1	14.0
394005.115	0	44	0.0	1.7	11.3
393574.72 B	0	45	0.0	1.9	12.7
LBr-40	4	35	10.3	3.1	20.7
394038.105	0	33	0.0	2.2	14.7
396082.7	0	43	0.0	0.83	5.5
392270.32	0	37	0.0	0.85	5.7
Panauti	0	22	0.0	2.05	13.7
BSUPO-3	33	38	46.5	2.19	14.6
K. Giriraj	0	25	0.0	0.66	4.4
388764.26	0	41	0.0	1.60	10.7
392206.35	0	67	0.0	1.90	12.7
Rosita (Ch)	**48**	**26**	**64.9**	**3.51**	23.4

Total test entries 45

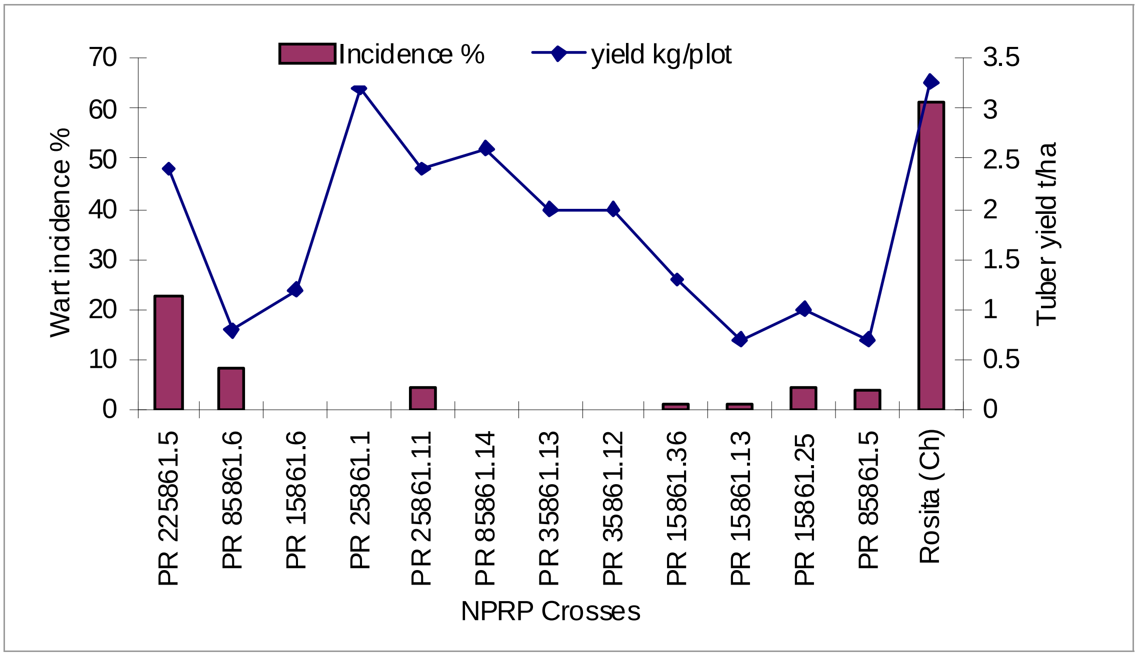

Figure 1. Performance of NPRP crosses against wart disease at Nigale in 2007/08

Black scurf management

There were significant differences in the disease index observed due to the treatments. The plots having healthy seed (pre basic seed) planted in sterilized plots showed minimum disease index by 6.8 % followed by 3% boric acid treated seed planted in sterilized plots (10.8%) and in seed and soil treated with *T. harzianum* (17.1%). Seed treatment with Thiophanate methyl was not found effective in controlling the black scurf disease under farmers field conditions (Table 4).

Treatments were assessed for impact on black scurf disease control based on the severity disease index. On an average disease control was achieved up to 70.9 % where disease free tubers planted in sterilized soil. Efficacy of *T. harzianum* showed effective control with 30.0% over the three crop seasons. Soil sterilization with Formaldehyde 1% had a role of controlling 14.8%. Role of infected seed tubers on developing disease severity was found higher than the *Rhizoctonia* infested soil.

There was no significant differences between treatments of 3% boric acid treated seed and of boric acid 2% concentration in the first two consecutive experimental years, whereas in the third year disease index was found significantly low in Boric acid 3% treated plots (Table 4). Despite of low mean disease index of three years due to seed treatment of boric acid 3% planted in sterilized soil (11.1%) farmers choose seed treatment with boric acid 2% planted in infected soil simply because of low cost on seed treatment and no need of formaldehyde application for soil sterilization.

Over all results of three years showed that planting healthy seed in sterilized soil was the best option for black scurf management. Farmers were found hesitating for using chemicals like formaldehyde for soil sterilization, which increases the cost of production. Evaluating the pros and cons of all treatments farmers preferred seed treatment with boric acid 2 percent. Application of antagonistic fungus (*T. harzianum*) to tuber treatment, soil treatment and drenching was found comparable with infected seeds planted in sterilized soil with formaldehyde (Table 4). In 2001 Tsror *et al* had also reported the efficacy of *T. harzianum* on pathogenic *Rhizoctonia* in reducing the incidence of black scurf on daughter tubers using naturally infested soil and contaminated seed tubers. Martin and Robert (2005), also have reported similar results on the efficacy of *T. harzianum* against *R. solani*.

Table 4. Black scurf disease index on potato tuber at harvest under field conditions during 2003/04 to 2005/06

Treatments	Disease Index				MDC* %
	03/04	04/05	05/06	Mean	
T1:Seed and Soil treatment with *T. harzianum*	17.7	18.7	16.1	17.5	30.0
T2:Boric acid (3 %) treated seed in sterilized soil	13.4	9.5	10.5	11.1	55.4
T3:Boric acid treated (2%) seed in infected soil	18.3	13.6	11.8	14.6	41.7
T4:Infected seed in sterilized soil	22.6	20.2	21	21.3	14.8
T5:Treated seed with ROKO fungicide in infected soil	25.4	26	16.8	22.7	9.1
T6:Healthy seed in sterilized soil	9.6	4.8	7.6	7.3	70.9
T7:Infected seed in infected soil (Farmer's practice)	27	29.3	18.7	25.0	0.0
F Test	**	**	*		
CV (%)	13.4	22.2	10.4		
LSD(0.05)	4.6	2.4	2.05		

* Mean disease control of three years

Tuber yield from the plot of pre basic seed planted in sterilized plot was highest (29.73 t/ha) followed by seed treatment with boric acid 3% planted in sterilized plot (27.7 t/ha) and *T. harzianum* applied plot (24.88 t/ha). This yield was comparable with the yield of boric acid 2% treated plot (26.04 t/ha). Among the results of three years, yield differences between the two treatments boric acid 2% and 3% in the last two experimental years were found at par. Significantly higher tuber yield was harvested *T. harzianum* treated plot (25.12 t/ha) as compared to farmers practice (Table 5). Results indicate that biological control through *T. harzianum* would be one of the new options for long-term black scurf management under mid western terai conditions of Nepal. When population of *T.harzianum* gets well established in the soil, disease could be controlled significantly in the succeeding years.

Table 5. Effects of different treatments and farmers acceptance score on potato tuber yield (t/ha) under field conditions

Treatments	Tuber yield (t/ha)				FAS (1-5)*
	03/04	04/05	05/06	Mean	
T1:Seed and Soil treatment with *T. harzianum*	27.41	25.12	22.11	24.88	2
T2:Boric acid (3 %) treated seed in sterilized soil	30.32	28.76	24.00	27.70	4
T3:Boric acid treated (2%) seed in infected soil	27.08	27.66	23.38	26.04	1
T4:Infected seed in sterilized soil	23.80	26.50	22.08	24.13	5
T5:Treated seed with ROKO fungicide in infected soil	24.81	22.89	21.71	23.14	5
T6:Healthy seed in sterilized soil	32.87	30.50	25.81	29.73	3
T7:Infected seed in infected soil (Farmer's practice)	23.61	22.49	21.39	22.50	
F Test	**	**	*		
CV (%)	4.54	4.47	7.15		
LSD(0.05)	1.58	2.7	2.89		

* Farmers acceptance score 1= highly accepted; 5 = poorly accepted

The tuber yield of three years was found in decreasing trend. The reason behind it could be the experiment conducted on highly fertile soil and better irrigation in the first year. On second and third year experimental plot was changed as per the farmers' crop rotation scheme. In addition, there was no rainfall during the crop period of third year.

Conclusion and recommendations

The participants did not accept sterilization of soil with Formalin in a large potato growing area. All the treatments connected with soil sterilization were rejected even yield was significantly higher (Table 5). Seed treatment with 2% boric acid planted in unsterilized soil was comparable with boric acid 3% along with soil sterilization. Therefore farmers selected lower dose of boric acid. As the impact of the experiment experiment potato seed producers of Mainapokhar, Bardiya followed seed treatment with Boric acid 2% and a total of 100 kg Boric acid was utilized for this purpose. Similarly, Application of *T. harzianum* produced the significantly higher yield than the check plot. These two treatments were considered as most effective and easy to use under farmers' conditions. Researchers, working with farmers, realized that participatory potato clone selection serves as best statistical tools for significant validation of the result.

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Gender relationships in production and commercialization of potato seed with small-scale farmers in the Central Andes of Ecuador

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Abstract

A gender analysis was conducted in the central Andes of Ecuador with the following objectives (i) to identify and analyze gender relationships and benefits in potato seed producers of the farmers' organization CONPAPA (*Consorcio de la Papa*) and (ii) to propose recommendations to improve the relationships among the actors of CONPAPA's seed system. A rural participatory diagnostic with gender approach was used to gather information about general characteristics, participation in community activities, potato-related activities, decision making, and personal, family and unpaid activities. This method promoted reflection among farmers about their roles according to gender. Main conclusions were the following: first, women are a critical component for seed production in CONPAPA; second, women are being empowered by becoming part of CONPAPA seed producers groups; third, becoming part of the CONPAPA seed producers groups might be overloading women capacity; and fourth, men are still attending the most important events and are in charge of taking the most important decisions. Several recommendations were made. (i) take extra care on using training materials adapted for women and doing the training events in their native language; (ii) promote women access not only to knowledge, but also to other resources, mainly credit, so they can run their own businesses; (iii) practice affirmative action and promote women leadership; (iv) be aware that new activities could be overloading women capacity and, therefore, start the intervention with few and simple activities; and (v) make explicit the contribution made by women to specific activities.

Keywords: Andes, women, gender analysis.

Introduction

Potato is the main source of energy in the Central Andes of Ecuador, especially for low-resource farmers. Nearly 80,000 families depend on this crop for food and income. Yields are low and farmers' organizations are weak. In 2003, the National Agricultural Research Institute of Ecuador (INIAP) with the support of the Papa Andina project at the International Potato Center (CIP) and funding from the Swiss Agency for Development and Cooperation (SDC) started the construction of multi-stakeholder platforms which helped to develop the *Consorcio de la Papa* (CONPAPA), a farmers' organization aimed at strengthening the entrepreneurial capacity of potato producers (Cavatassi et al, 2009).

One of the strongest points of CONPAPA is the implementation of a seed system. This includes using high quality seed from INIAP, training of farmers on how to re-use their own seed, and an internal quality control protocol (Montesdeoca et al., 2006). Women participate actively in CONPAPA's seed system and, therefore, INIAP and CIP-Papa Andina agreed to implement a study to analyze gender relationships. This document presents the results of the analysis.

Gender analysis helps to explain the mechanisms and dynamics of agricultural research and extension problems in a certain context, in order to understand them and obtain sustainable and equitable results. The objectives of this study were (i) to identify and analyze gender relationships and benefits in seed producers of CONPAPA and (ii) to propose strategies to improve the relationships among the actors of CONPAPA's seed system.

Methodology

This study was done in the provinces of Cotopaxi, Chimborazo and Tungurahua located in the central Andes of Ecuador. This region concentrates 55% of potato production of Ecuador and is among the poorest in the country. One location was sampled in Cotopaxi (Cumbijín), two in Chimborazo (Calerita and Ballagán), and three in Tungurahua (San Andrés and Pilahuin). All these locations are located between 2500 and 3600 m.a.s.l.

Farmers were selected using the following criteria: producers of potato seed and belonging to the CONPAPA association of seed producers (hereafter referred to as 'CONPAPA seed producers'). In addition, a group of potato seed farmers not belonging to the CONPAPA seed producers was selected (hereafter referred to as 'individual seed producers'). In the CONPAPA seed producers, 21 families (17 represented by women and 4 by men in the association) and 118 of their family members (64 women and 54 men) were included in the study. In the individual seed producers, 21 families and 114 family members (58 women and 56 men) were included in the study.

A rural participatory diagnostic with gender approach (Adamo et al., 1998) was used to gather information about general characteristics, participation in community activities, potato-related activities, decision making, and personal, family and unpaid activities. This method promoted reflection among farmers about their roles according to gender. Several techniques were used: interviews, workshops and direct observation. Descriptive statistics were used to analyze the information (Mayorga et al., 2004).

Results

Table 1 shows the main characteristics of the families included in this study. Gender is balanced in the CONPAPA seed producers and in the individual seed producers. Distribution across age shows that most members are between 18 and 56 years old. Most family members have incomplete primary education, and the percentage of illiteracy is relatively low in both groups. There are three sources of income: potato seed production, off-farm employment and agriculture in general. In the CONPAPA group, potato seed production is the most important one, followed by off-farm employment and agriculture in general. A remarkable 18% of women participate in potato seed production, while off-farm employment is dominated by men. In the individual seed producers, there is no formal business of producing potato seed and, therefore, agriculture in general is the main source of income. As in the CONPAPA group, off-farm employment is dominated by men.

In average and in both groups, women participation in general community activities is higher than men participation (Table 2). General activities are for example, ***assemblies, election of authorities and task groups, strikes, and*** *mingas* (collaborative ***community work traditional in the Andes). In the CONPAPA seed producers group, election of task groups, strikes and*** **mingas** ***are attended mostly by women, while assemblies and election of authorities are attended mostly by men, though women participation is high. In the individual seed producers group, women participation is higher than men participation in strikes and*** **mingas*****, while there is no clear trend regarding gender about participation in assemblies and election of authorities and task groups. In specific activities for the CONPAPA seed producers group, men dominate participation (Table 2).***

In the CONPAPA seed producers group, women tend to decide on topics related to food, clothing, vegetable and animal management, while men tend to decide on children education, selling products, cash management, input use and nearly all activities related to potato production as organized group (Table 3). In the individual seed producers group, all decisions are taken mostly by men.

In the CONPAPA seed producers group, most potato-related activities are done mostly by women (Table 4). Exceptions are soil preparation, pest control and selling the production. In the individual seed producers group, all potato-related activities are done mostly by men. It is remarkable that women in the CONPAPA seed producers groups participate much more on pest control and especially in selling the production that their peers in the individual seed producers group.

Family and unpaid activities in the CONPAPA seed producers groups are done overwhelmingly by women (Table 5). Men do one activity at a time, while women do several activities simultaneously. For example, women take care of babies while shepherding and spinning wool. This explains why women spend 46 hours per day on these activities, while men spend 24 hours.

Finally, qualitative information showed that most women are not able to fully understand the training they receive from INIAP and other OGs and NGOs, as women prefer to communicate orally in Quichua and not in written Spanish, as eventually occurs in training events. Women also complained about low access to credit.

Discussion

Although the sample size was relatively small and the data was mostly qualitative, this study suggests the following conclusions. First, women are a critical component for seed production in CONPAPA. They attend events such as assemblies, training workshops, etc. (Table 2), decide on important aspects related to seed production (Table 3) and, more importantly carry on most of them (Table 4). As result, this activity is becoming the single most important source of family income, displacing off-farm employment by men (Table 1). Second, women are being empowered by becoming part of CONPAPA seed producers groups. For example, they decide in higher proportion and in more topics than women who do not belong to the CONPAPA groups (Table 3). They also sell the production almost as often as men do and nearly twenty-fold higher that their peers who do not belong to CONPAPA (Table 4). Third, becoming part of the CONPAPA seed producers groups might be overloading women capacity. It is staggering the activities that women do, which seems not be compensated by men (Table 5). Finally, men are still attending the most important events (Table 2) and are in charge of taking the most important decisions (Table 3).

Taking as a whole, the intervention of INIAP of training women to become seed producers seems a good decision. However, several recommendations could be made. (i) take extra care on using training materials adapted for women and doing the training events in their native language; (ii) promote women access not only to knowledge, but also to other resources, mainly credit, so they can run their own businesses; (iii) practice affirmative action, as 'treating unequals as equals is to perpetuate inequality', and promote women leadership; (iv) be aware that new activities could be overloading women capacity and, therefore, start the intervention with few and simple activities (e.g., growing small potato plots); and (v) make explicit the contribution made by women, if not to all activities, at least to those related to potato production.

The capacity of CONPAPA to organize farmers and to provide access to markets was not part of this study, but this is a critical point to understand the success of women seed producers. CONPAPA provides access to new technologies, training, technical support, credit, and markets that demand high quality tubers. Seed is produced only by demand, it is checked by an internal quality control process, and is sold to other CONPAPA's farmers at a convenient price for both parties. In that manner, seed producers are encouraged to produce high quality tuber seeds, because they are rewarded with a good price. In addition, seed producers are seeing as top potato producers within their communities, which in turn increase their self esteem.

Table 1. General characteristics (%) of family members from CONPAPA seed producers and individual seed producers

Characteristics	CONPAPA seed producers (n = 118)		Individual seed producers (n = 114)	
	Women	Men	Women	Men
Gender distribution	46	54	51	49
Age				
Between 1 and 11 years	15	10	4	9
Between 12 and 17 years	7	3	6	8
Between 18 and 56 years	21	27	36	24
Older than 56 years	8	9	4	9
Education				
Adult literacy courses	7	1	3	3
Primary incomplete	24	25	13	18
Primary complete	8	9	8	16
Secondary incomplete	2	3	12	12
Secondary complete	4	5	5	3
Undergraduate	0	2	1	0
None	6	4	3	3
Source of income				
Potato seed production	18	25	0	0
Off-farm employment	2	29	3	33
Agriculture in general	15	11	35	29

Table 2. Participation by gender (%) in community activities for two groups of potato seed producers in the central Andes of Ecuador

Community activities	CONPAPA seed producers (n = 21 families)		Individual seed producers (n = 21 families)	
	Women	Men	Women	Men
General activities				
Assemblies	43	57	76	24
Election of authorities	43	57	62	38
Election of task groups	71	29	29	71
Strikes	81	19	71	29
*Mingas**	76	24	76	24
Mean	**63**	**37**	**63**	**37**
Specific activities for CONPAPA seed producers				
Training workshops	38	62	N.A.**	N.A.
Assemblies	43	57	N.A.	N.A.
Meetings with authorities	48	52	N.A.	N.A.
Task groups	43	57	N.A.	N.A.
Field visits	43	57	N.A.	N.A.
Mean	**43**	**57**		
Total mean	**53**	**47**		

***** Collaborative ***community work traditional in the Andes.***
** N.A. Not applicable

Table 3. Participation by gender (%) in decision making for two groups of potato seed producers in the central Andes of Ecuador

Topic to be decided:	CONPAPA seed producers (*n* = 21 families)		Individual seed producers (*n* = 21 families)	
	Women	**Men**	**Women**	**Men**
Family decisions				
Children education	38	62	33	67
Food	67	33	52	48
Clothing	67	33	43	57
Vegetable and animal management	62	38	43	57
Selling products	43	57	33	67
Cash management	14	86	40	60
Input use (manure, water, etc.)	5	95	22	78
Mean	**42**	**58**	**38**	**62**
Decisions related to seed production as organized group				
Area planted and seed	38	62	N.A.	N.A.
Variety	28	76	N.A.	N.A.
Planting date	26	74	N.A.	N.A.
Pest control	29	71	N.A.	N.A.
Harvest	67	33	N.A.	N.A.
Selling seed	29	71	N.A.	N.A.
Cash management	24	76	N.A.	N.A.
Income distribution	24	76	N.A.	N.A.
Mean	**33**	**67**		
Total mean	**38**	**62**		

Table 4. Participation by gender (%) in potato-related activities for two groups of potato seed producers in the central Andes of Ecuador

Potato-related activities	CONPAPA seed producers (*n* = 21 families)		Individual seed producers (*n* = 21 families)	
	Women	**Men**	**Women**	**Men**
Soil preparation	24	76	23	77
Buying inputs	76	24	1	99
Planting	73	27	43	57
Hilling and weeding	75	25	38	62
Pest control	24	76	0	100
Harvesting	76	24	38	62
Selling	43	57	2	98
Mean	**56**	**44**	**21**	**79**

***** Collaborative ***community work traditional in the Andes.***

** N.A. Not applicable

Table 5. Time dedication per day (hours) by gender in personal, family and unpaid activities for CONPAPA seed producers in the central Andes of Ecuador

Activities	Women	Men
Sleeping	7	7
Personal care	0.5	0.5
Milking*	1.5	1
Preparing and serving breakfast*	1.5	0
Breakfast	0.5	0.5
Off-farm employment	0	8
Housekeeping*	1	0
Shepherding*	8	0
Send children to school	0.5	0
Babycare*	10	0
Cutting forage*	1.5	0
Feed small animals*	1.5	0
Feed large animals*	2	0
Preparing and serving lunch*	1.5	0
Lunch	0.5	0.5
Receive children from school	0.5	0
Laundry and sewing clothes, spinning wool*	1	0
Managing vegetable garden*	6	2
Homework with children	0	1
Rest	0.5	0.5
Supper	0.5	1
Commuting	0	2
Total	**46**	**24**

* Activities done by women simultaneously with other activities

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Scaling-up of Farmers Field School (FFS) in Peru. CIP's contribution to the process

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Abstract

The FFS method was introduced and adapted to potato-related problems in Peru by the International Potato Center (CIP) and the NGO CARE-Peru in 1997. Since then, a scaling-up process of the methodology has taken place following three phases: 1) validation (1997-1999) in which CIP and CARE adapted and assessed FFS; 2) replication (2000-2004) in which a large FFS-IPM project lead by FAO was implemented and trained about 150 facilitators, CIP-CARE experience contributed to replication phase; 3) institutionalization (2005-2008) in which several institutions have started to use the methodology on their own. Up to 2008, a total of 77 agriculture-related institutions in Peru have used the FFS methodology in different crops, particularly potatoes, and in some cases in livestock. The results of CIP's methodological research about FFS have been directly or indirectly shared with institutions during the three scaling-up phases. The analysis indicates that there has been a process of scaling-up of the FFS methodology in Peru, which is contributing to improve farmer access to technological information. However, the institutionalization process has been influenced by several factors such as the limited access to formal training for facilitators, limited financial resources to cover the costs of FFS implementation, slowness in institutional decision-making to adopt the methodology as part of their strategies, field workers being overloaded with responsibilities, and instability within institutions. The quality of FFS depends on the quality of the training that facilitators can receive. Hence, one of the challenges for the future of this methodology in Peru is how to provide training to facilitators, taking advantage of existing experiences, so that the process of scaling-up and out could continue with sufficient quality.

Keywords: FFS, scaling-up, Peru.

Introduction

Facilitating farmer access to appropriate information has become a common preoccupation among donors and agriculture-related organizations in the last decades. The assessment of several research and capacity building projects has shown limited impact at farmer level despite of large investments in agricultural research and extension. Additional analysis of the reasons why impact has not been achieved shows that farmers have limited access to information, and when they have access to it, information is presented in ways that limit understanding and transformation into knowledge and decision-making. Several organizations have started to explore ideas to solve this problem. For example some participatory research and training methods began to be proposed since the 1980s. That is the case of the farmer field school (FFS) methodology developed by FAO initially to deal with information about rice IPM. The method uses principles of adult education, which were developed in the 1960s by Freire (1970), in order to facilitate farmers' understanding of complex topics such as the biophysical principles involved in pest control. For farmers to understand such concepts, they need to be actively involved in learning activities, through which they learn by observing carefully what happens in the fields, and based on the observations, they enhance their capacities to make decisions about management options (Gallager, 2003).

Since the 1980's the method has been scaled-up and out in several places; first to deal with rice IPM, but latter in a number of crops and subjects. Evaluations have shown positive effects on pesticide reduction and increased yields in several countries (van den Berg, 2004; Godtland et al., 2004); but also the approach has been criticized because of its relatively high cost (Ricker-Gilbert et al., 2008). Most of the studies published so far have focused on the process of how to run FFS or on the results of FFS at farmer level. However, studies about scaling-up processes and the factors that influence them have been limited.

This paper aims at analyzing the scaling-up and out process of the FFS approach using Peru as a case study, and it is based on documentary analysis and interviews carried out during 2008 with 37 representatives of institutions involved in FFS implementation.

Introduction of FFS in Peru

FFS were introduced to Peru in 1997 by the International Potato Center (CIP) to work specifically on potato late blight. This process was initiated by a CIP staff member who had worked on rice FFS in Asia. At that time, CIP had an agreement for cooperation with CARE-Peru, and NGO working in the Andes. CARE and CIP had worked since the early 1990s on projects related to integrated pest management (IPM). The previous experience of both organizations had shown that innovative training methods were needed to support farmer understanding of IPM. However, most of the experience up to that point was on insect IPM. When CIP started to work with potato late blight, the most important potato disease, the team members realized soon that working with microorganisms was even more complex and required specific training methods. Hence the FFS approach was the best bet at that time (Nelson et al., 2002; Ortiz et al., 2004; Ortiz et al., 2008). Figure 1 shows the three phases related to FFS scaling-up and out in Peru.

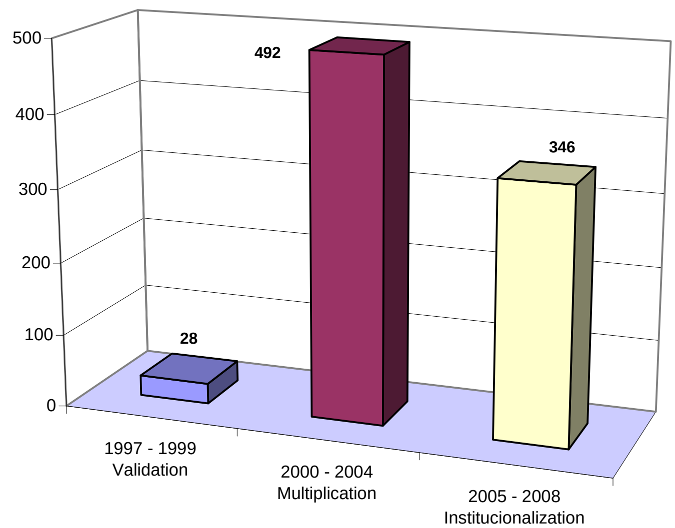

Figure 1. Phases for scaling - up and out of FFS in Peru, showing the number of FFS implemented between 1997 and 2008

The validation phase (1997-1999)

The main objective of CIP and CARE at the beginning of the FFS experience was to adapt the method to the potato crop and particularly to late blight management under Andean conditions. Both CIP and CARE had experience with IPM for managing the Andean Potato Weevil and the Potato Tuber Moth. However, they realized that working with disease control required developing specific teaching/learning activities and the FFS approach represented an option to test. CIP and CARE team started to develop teaching/learning activities in a participatory way following the principles of FFS. However, they realized that methodological backstopping was needed in order to do a better adaptation. Because of this, CIP established contact with FAO and agreed to collaborate for a training of trainer (TOT) course, which was organized in Ecuador in 1999 and lasted 3 months. One CIP staff member and 7 CARE staff members, along with 27 other institutional representatives from Peru, Bolivia and Ecuador participated in this TOT. The training helped the CIP-CARE team to continue adapting the FFS approach to the potato crop in the Andes. The adaptation process resulted in field guides (Bazan et al., 2002), which were validated in 21 FFS between 1997 and 2001 with the support of the International Fund for Development (IFAD). The project supported by IFAD was also implemented in Bolivia, Uganda, Ethiopia, Bangladesh and China, where the FFS method was also being adapted to the potato crop.

The main lessons of the validation phase were that the FFS methodology was effective in terms of contributing to farmer learning of new technical knowledge, which in turn was related to improved productivity (Godtland et al., 2004; Ortiz et al., 2004; Zuger, 2006). Another lesson was that farmers wanted more information about other pest-related problems such as other insects and diseases, and also about crop management in general, but this added complexity to FFS. This phase also showed that participatory research should to become integral part of the FFS process because of the need to test new technologies with farmers, particularly to control potato late blight, which varied from site to site, according to agroecological conditions. For this reason, CIP called the approach farmer participatory research through FFS (Ortiz et al., 2004).

The replication phase (2000-2004)

Between 1997 and 2001, CIP and CARE had sufficient experience for thinking about scaling-up and out FFS for the potato crop in Peru. In addition, there were also similar experiences in Ecuador and Bolivia, and CIP also had FFS-related experiences in Asia and Africa at that time. In Peru, FAO initiated a large IPM-FFS project and key CARE staff who have learned about IPM with CIP was hired to support this project. In this way the CIP-CARE experience was shared and contributed to the replication phase. The FAO project expanded the scope of work in geographical and thematic terms. FFS were replicated in potatoes, but also in cotton, coffee, maize, citric fruits, peanuts, beans, banana, aromatic herbs, mango, artichoke and also in livestock (Figure 2). A total of 492 FFS were implemented directly or indirectly under the influence of the FAO Project between 2000 and 2004 and a total of 145 staff members from 56 institutions received training about the methodology as part of this project (Groeneweg et al., 2004).

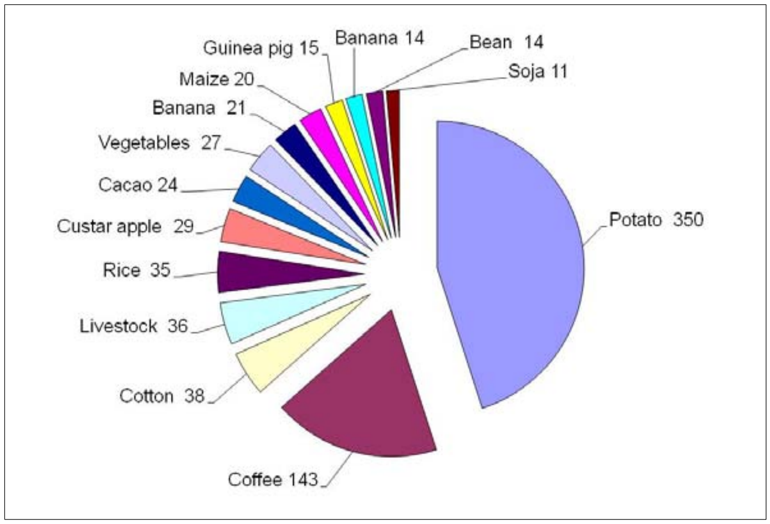

Figure 2. Number of FFS per topic implemented in Peru. 1997 – 2008

The main lessons of this phase were that for FFS to be implemented institutions needed training and funding, and that institutional efforts were needed to maintain or enhance the quality of FFS (Malarin, 2003). However, a limitation was that participating institutions still perceived FFS as something external to their normal structures and strategies, providing only part-time staff for the implementation. The FAO project provided a number of institutions with the opportunity of experiencing FFS and learning in the process, which contributed the further adaptation of the method to other topics and contexts. Douthwaite (2002, 2009) highlights the need to learn from experience in order to innovate, and that was what happened during the replication phase of FFS in Peru.

The institutionalization phase (2005 – 2008)

After the FAO project concluded, the scaling-up and out process entered a period of scarcity of external funds. However, at the same time, the investments made for training staff from a number of institutions, and the organizational learning process initiated in the previous phase started to pay off. As a result, institutions started to implement FFS using their own funds. For example, CARE developed a FFS project to manage native fruit trees, incorporating marketing concepts (CARE-Peru, 2006). At the same time, CIP and CARE started to work in another project related to assessing participatory research and training methods, including FFS, supported by IFAD, and implemented also in Bolivia, Ethiopia and Uganda. Results of this project indicated that for participatory research and training methods to succeed, the methods should facilitate farmer access to new knowledge, skills and technologies to solve their main problems. In addition, this project also identified some factors that constrain institutionalization of FFS, for example, limited funding sources, which influenced a limited logistic support for FFS implementation, misconception among institutions that field staff could run FFS as a part-time activity on the top of their normal duties, time constraints on the part of facilitators and researchers involved was also highlighted, because this type of method requires relatively more preparation, which has implications for its cost. Staff instability within institutions was also indentified as a limiting factor because it did not allow facilitators to grow in their skills and interest about participatory research and training methods. In addition, changes in, and discontinuity of, institutional policies influenced FFS implementation (Ortiz et al., 2008; Ortiz et al., 2009).

Despite of some of the limitations described above, a total of 35 government, non-government and private organizations reported having implemented FFS in 2008. The topics covered have increased including crops such as organic banana, soja, quinoa, grass for livestock, organic vegetable production, native fruits, and other topics such as agro forestry, Peruvian guinea pigs and pig production, management of fish farms, food security, nutrition, marketing and family health (Figure 2). This figure shows that some of the new topics in which FFS have been used include cash crops and other income generation activities (case of coffe, organic banana, cacao, vegetables and fish farms), which represent a shift from the original orientation to staple crops, such as potatoes, during the validation phase. These 35 organizations have already inserted FFS principles as part of their formal operational procedures and plans. Therefore, there is evidence to claim that an institutionalization process of the FFS methodology is happening in Peru. Some preliminary lessons of this phase indicate that the FFS approach has sufficient flexibility to be adapted to a number of needs, topics and contexts, including income generation and market oriented activities. However, as the number of organizations interested in FFS increases, there is also need for having more trained facilitators. One of the challenges is how to continue a process of training which can ensure sufficient number of facilitators who could use and implement quality FFS.

Concluding remarks

After ten years of the introduction of the FFS methodology to Peru, an scaling-up process has happened and a number of institutions had access to training about this approach, and have included it as part of their formal plans. At the same time, a scaling-out process has occurred in terms of the number of FFS implemented, which were 4 in 1997 and a total accumulated of 866 implemented up to 2008. Given the interest among organizations about FFS, and the diversity of on-going experiences, there is the need to learn from existing experiences, share information, and try to form some formal or informal network of organizations interested in continuing the process in Peru.

As indicated above, a total of 866 FFS have been implemented between 1997 and 2008; assuming 20 participants in each FFS, this would mean a total of 16,062 participants. This number represents only 0.92 % of total farmers in Peru, and if we look at only potato farmers, about 1.1% would have been reached through FFS. Therefore, there is still a long way to go to increase coverage, which calls for a better interaction and coordination among local, regional and national government institutions with NGOs and the private sector interested in this methodology and agricultural development in general.

The initial methodological research outputs of the CIP-CARE experience have resulted in outcomes related to methodological innovation by a number of research and development oriented organizations in Peru. The challenges related to the scaling-up and out of this method in Peru include aspects such as the need to have more stable sources of funding for implementing FFS. There is hope that this may happen if the method could become part of the activities of regional governments such as in the case of Ayacucho region in Peru. Another challenge is how to continue providing training to new facilitators and institutions interested in the methodology. At the moment, there is a lack of training sources, which may have influenced negatively the quality of FFS. The method has sufficient flexibility and could be easily adapted to a diversity of topics, including specific market-oriented activities, but also could be used to facilitate farmers' understanding of, and preparedness for, climate change. However, FFS represent just one option, which would not be enough to solve the problems related to agricultural development. A combination of methods properly selected according to contexts and topics would be advisable to reach a larger number for farmers. For this purpose, research and development organizations should conduct methodological research jointly and learn in the process.

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