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.

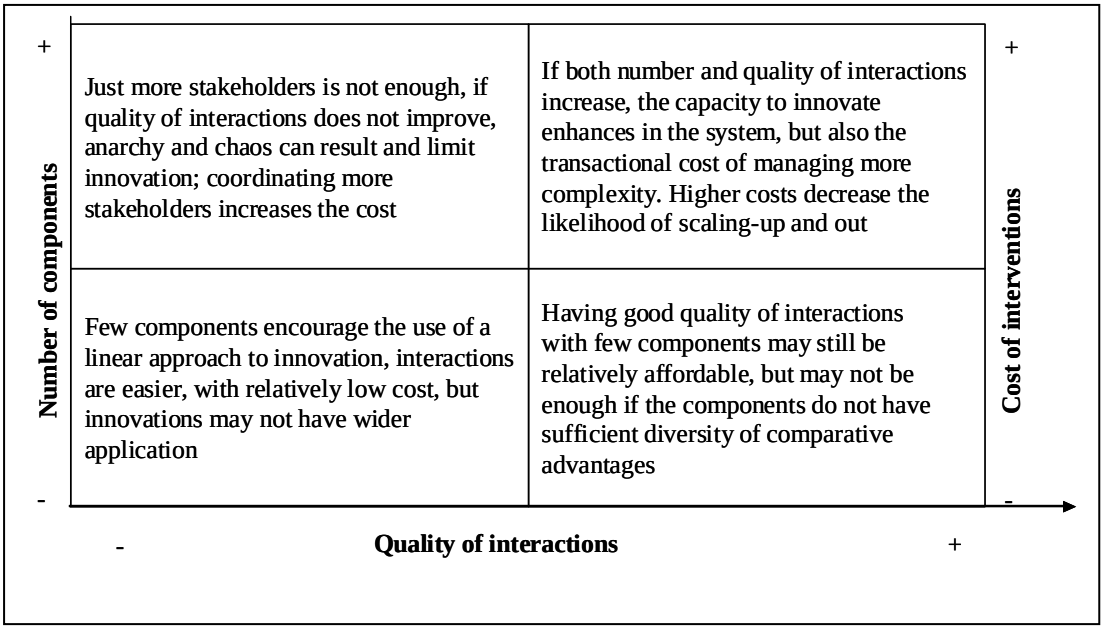

Figure 1. Potential relationship between the number of components, quality of interactions and costs for enhancing the efficiency of innovation systems.

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