Making interventions work on the farm

Unravelling the gap between technology-oriented potato interventions and livelihood building in Southern Ethiopia



Yenenesh Tadesse

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Thesis committee

Promotor

Prof. Dr P.C. Struik

Professor of Crop Physiology

Wageningen University & Research

Co-promotors

Dr C.J.M. Almekinders

Assistant professor, Knowledge, Technology and Innovation Group

Wageningen University & Research

Prof. Dr R.P.O. Schulte

Environment, Soils and Land Use Research Department

TEAGASC, Johnstown Castle, Ireland

Other members

Prof. Dr J.S.C. Wiskerke, Wageningen University & Research

Dr L. O'Brien, TEAGASC, Carlow, Republic of Ireland

Dr J.A.A. Swart, University of Groningen

Dr K.K.E. Descheemaeker, Wageningen University & Research

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Thesis

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Abstract

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Poor adoption of modern technologies in sub-Saharan Africa is one of the major factors that limit food production and thereby threaten food security of smallholder farmers. This is despite the potential and emerging success stories of new technologies in increasing productivity of smallholder agriculture. Explanations for low uptake of technologies are diverse. Some studies associated it with characteristics of the farmers and their farm; others attributed it to poor access to information about a particular technology, while some others recognize the importance of technology attributes. Farmers' adoption decision is shaped socially and the farming practices are changing, not only because of the technical changes introduced, but also because of changes in social circumstances among smallholders. All these possible reasons did, however, miss largely important insights on how local complexities influence adoption. The research presented in this thesis analyses the social dynamics of technology-oriented interventions. More specifically, the study assessed the influence of technology introduction strategies, social networks and social differentiation on the adoption, dissemination and effects of potato technologies. As a case, it used interventions introducing improved potato technologies in Chencha, Southern Ethiopia. The field work combined individual and group in-depth interviews, household surveys and field observation for data collection.

Results show that the efforts to introduce technologies for improved potato production to progressive farmers with the assumption that farmers will eventually adopt, once they become familiar with the technology is a distant prospect. Some of the production practices - agronomic field and storage practices - failed to spread to poor farmers as expected, while the majority of agronomic practices fitted well with wealthy farmers. This resulted in diverse outcomes and strategies for livelihood improvement at household level. Access to the technologies and the necessary resources and diverse needs for technology were important factors in explaining variation in adoption and effects of technology across wealth categories. Tracing the seed diffusion through farmers' networks showed that not all households had equal access to improved seed potatoes, mainly because of social barriers formed by

differences in wealth, gender and religion, and because the type of personal relationship (relatives, neighbours, friends and acquaintance) between seed providers and seed recipients affected farmer to farmer seed sharing. In addition, the set-up of farmer-group based seed production demands resources and faces contextual challenges, which could be addressed through a long-term approach that engages continually in diagnosis and responding to the emerging social as well as material challenges. Development practitioners, however, took organizing group initiatives as a one-time process of design and start-up activity. Thus, clean seed potato production and dissemination through farmers' organizations could not be sustainable. In conclusion, the present study has indicated that through providing special attention to the social dynamics researchers can arrive at better understanding of constraints affecting technology adoption. This implies effective interventions for a range of farm contexts involve not only finding technical solutions but also integrated understanding of farmers' production conditions and existing social dynamics.

Keywords: Agronomic practices, technology adoption, food security, farmer seed system, seed potato cooperatives, seed quality control, wealth classes.

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CHAPTER 1

General introduction

Technology interventions for smallholder farmers in sub-Saharan Africa

Agriculture in sub-Saharan Africa and in Ethiopia in particular, is dominated by smallholder farmers, using traditional methods. Smallholder farmers occupy the majority of land, contribute up to 80 percent of the food supply and make up a high proportion of the economy. Smallholder farming has therefore often been proposed as key to solving food insecurity, poverty and rural development (Reutlinger and Pellekaan, 1986; Worldbank, 2007, Gebremedhin and Jaleta, 2009; FAO, 2012; IFAD and UNEP, 2013; Gollin, 2014). The agricultural production of most countries in the region, however, continues to be based on subsistence. The food production has declined sharply for decades and the food supply is still unsecure, and this resulted in a widespread food crisis and an increasing dependence on food imports. This trend is mainly associated with the low production capacity of smallholders (Sumberg, Gilbert and Blackie, 2004; Dadi, Burton and Ozanne, 2004; Byerlee *et al.*, 2007). To meet demands for food, there is an urgent need to increase the productivity of smallholder agriculture. Efforts to ensure food security need to focus on interventions introducing new technologies which encompass improved farming practices, new varieties, more nutritious crops, fertilizers, credit and storage facilities, because expanding the area under cultivation to address food insecurity is severely limited by increasing human and livestock population pressure (Anderson, 2007; Adjei-Nsiah *et al.*, 2008; Beyene, 2008).

The experience and evidence from countries within and around the sub-Saharan African region indicate that agricultural technologies could transform not only the smallholder sector, but also the entire national economies of countries in the region (see Gabre-Madhin and Haggblade, 2004). At the same time, studies indicate that the adoption and use of new technologies among smallholder farmers is slower than foreseen, with large variation in the response to the same intervention (Röling, 1988; Meijer *et al.*, 2015; Walker and Alwang, 2015). The farm conditions under which smallholders practice their farming can be different from the situations in which many agricultural technologies have been developed. Smallholder farmers operate under diverse agro-ecological, socio-economic and farm management conditions, which shapes their technology-use, varying with social groupings of farmers (de Steenhuijsen Piters, 1995; Sumberg, Okali and Reece, 2003; Giller *et al.*, 2006). It is these features of smallholder farming that lead to the emerging views that social differentiation, which creates various social categories of farmers in the community, plays a key role in understanding the variation in adoption of agricultural technologies.

This study contributes to better understanding of this 'bigger picture' by analysing the social context of potato farming. The focus here is on interventions for improved potato (*Solanum tuberosum*) production in smallholder farming, using Chencha Wereda, Gamo Gofa Zone, Southern Nations, Nationalities and Peoples Regional State, Ethiopia, as the research area. Taking the complexity and social dynamics of farming into account enables to have insights on possibilities and opportunities for improving the contribution of smallholder farmers to agricultural development.

Problem statement

In smallholder agriculture, many improved production technologies are poorly adopted. To explain this phenomenon, a considerable amount of research has been conducted. Some studies associated the adoption decisions with household specific factors: education, age and household size. Farmers with higher level of education, for instance, are open to technologies because they have better ability of evaluating the new technologies. This helps them to better understand the risk and uncertainty associated with the new technologies (Feder, Just and Zilberman, 1985; Kebede, Gunjal and Coffm, 1990; Nkonya, Schroeder and Norman, 1997). Other authors highlighted the importance of communicating information regarding new technologies. The dissemination of information about the characteristics of the new technologies takes time. Potential users with better access to extension services are well aware of the advantage of the technologies and this will ultimately result in adoption. Those with low opportunities to access information will also eventually adopt it, once they become familiar with the benefits of the technologies. For this reason, extension professionals continue to promote technologies that farmers persistently reject, without questioning if technologies being promoted are indeed appropriate (Argarwal, 1983; Röling, 1988; Adesina and Zinnah, 1993; Anderson and Feder, 2007; Meijer *et al.*, 2015). On the other hand, Chamber, Pacey and Thrupp (1989) and Reece and Sumberg (2003) attribute the decision to adopt or reject technology neither to the farmer characteristics nor to the opportunities to access information, but to the appropriateness of the technology. Technologies that do not fit the end users' objectives, constraints, strategies and expectations are less likely to be adopted. For example, technologies that demand expensive external inputs have low adoption rates.

Although technology adoption is commonly understood as a binary choice between adopting and rejecting technologies, introduction of new technologies is in reality followed by a

dynamic process of adoption (either wholly or partially), adaptation or rejection (Feder, Just and Zilberman, 1985; Van der Ploeg, 1994; Sumberg, Okali and Reece, 2003; Glover, Sumberg and Andersson, 2016). Analysis of adoption, adaptation or rejection of technologies by farmers may, therefore, require a socially differentiated view of farmers' decisions and rural livelihoods. Thus far, the social context underlying the complexity of technology adoption, however, has received scant attention from researchers. To bridge this gap, there is a need for a better understanding of this context, which might result in more successful initiatives for the introduction of improved technologies, and thus to greater overall returns from investments in agricultural technologies.

Thesis objective and research questions

This study aims to improve the understanding of how social differences influence the adoption of the new potato varieties, and potato cultivation and storage practices. Such understanding will generate useful insights for agricultural interventions to be accompanied by successful adoption of technologies. Our analyses will also provide insight into farmers' responses to interventions promoting new production practices in socially differentiated communities, and as a consequence, may lead to effective targeting of development interventions. The following research questions guide this thesis:

1. How do farmers cultivate potato? What factors explain the variation in potato technology adoption?
2. How do social differences influence the farmer-to-farmer seed potato sharing?
3. How do farmer-groups engage in quality seed potato production and marketing?
4. What is the impact of introducing potato technologies at household level?

Background

The role of non-governmental organizations in agricultural extension

Historically, Africa's governments have been heavily involved in the provision of agricultural extension services (Farrington, 1995; Dinar, 1996; Feder, Willett and Zijp, 2001). In the 1980s, however, structural adjustment programmes have been instituted to shift from a state-led model to a more market-based system that prioritizes private ownership and competitive

markets. Such kind of policy reform prevented the state from influencing the working of the economy as a means to improve the national economic performance (Riddell, 1992; Dollar and Svensson, 2000; Rono, 2002). In addition, because of the declining capacity of many governments, technical and managerial assistance to the farm sector has been reduced (Farrington, 1995). Public extension services are also often criticized for top-down and inflexible approaches (Lipton, 1988; Ajieh, Agwu and Anyanwu, 2008). State withdrawal and declining capacity have both challenged the performance of public agricultural extension. In response, the provision of extension services was broadened beyond the public domain to include a range of non-government organizations (NGOs) (Bebbington and Farrington, 1992; Farrington, 1995; Mercer, 1999).

In this environment, NGOs have been instrumental in analysing problems and in adapting and transferring different agricultural technologies to farmers (Cromwell, 1993). It is assumed that NGOs have the capacity for responding flexibly and rapidly to grass-roots needs and to changing circumstances because of their independency from the state, their openness to innovation and their sensitivity to local conditions (Chambers, 1996; Fowler and Bekard, 1996). More importantly, their institutional and methodological innovations consistent with their wider participatory and empowering approaches facilitate the dissemination of technologies among small producers (Bebbington and Farrington, 1992).

In contrast to these positive views of NGOs, others are questioning the performance of NGOs because they face different challenges which constraints their efforts in transferring technologies to farmers. First, NGOs are dependent on donor support and they have small size in that it minimizes their capacity of prioritization and implementation of long-term development programmes. Donors are mostly interested in short-term and concrete outputs (Eicher, 1989; Kaimowitz, 1993). Secondly, NGOs are unaware of the current research in their fields and the experience of other NGOs. This is because their interventions are found mainly in remote locations and are small in scale, which restrict their access to national research networks (Bratton, 1989; Vivian and Maseko, 1994). It means NGOs may not be fully equipped to handle some of the complex tasks of agricultural development. Thirdly, excessive costs diminished the likelihood that NGOs could achieve financial viability. An assessment of 19 NGOs engaged in seed distribution in Africa, for instance, indicated that the cost of small scale seed production per unit of distributed seed among NGOs was higher than

the level incurred by government seed agencies. Seed distribution through NGOs had high overhead and transportation costs (Wiggins and Cromwell, 1995). Fourth, sometimes NGOs have dominant views of how agricultural technologies should be promoted which might also hinder optimal solutions. For example, faith-based NGOs promoted conservation agriculture in African smallholder farmers as scale neutral and applicable across different farming conditions. In contrast to this, NGOs based on scientific experimentation proposed different recommendations that took into consideration smallholders' agro-ecological and socio-economic diversity (Andersson and Giller, 2012).

Challenges for improving potato production and productivity in Ethiopia

The introduction and promotion of improved potato technologies including improved potato varieties along with improved crop management practices are the main strategies of the Ethiopian government in order to fully benefit from the potential of the potato sector (Woldegiorgis *et al.*, 2008; Hirpa *et al.*, 2012; Tesfaye *et al.*, 2013). Potato in Ethiopia is among the important root and tuber crops that can reduce poverty and contribute to household food and nutrition security because it has a short growing season and it is more productive compared to other major crops (FAO, 2008; Gildemacher *et al.* 2009; CSA 2009). Potato is produced in two main production seasons - *Meher* (June to October) and *Belg* (March to May) - within altitudes of 1500 to 3200 m asl (FAO, 2008). The country has three main potato growing regions: Amhara, the Southern Nations Nationalities and Peoples' Region (SNNPR) and Oromia (Haverkort, 2015). The production and consumption of potato are increasing because of the population growth and changing consumption patterns among urban populations (Tesfaye *et al.*, 2010). Smallholder farmers could benefit directly from potato production as it is an integral part of their farming systems and it is efficient in converting agricultural inputs into a high quality food (Woldegiorgis *et al.*, 2015). Potato also contributes energy and substantial amounts of high quality protein and essential vitamins and minerals (Horton, 1987; Demo *et al.*, 2015). In addition, it is not at risk of international price fluctuations unlike major cereal crops, as it is mostly traded in local and national markets (Gildemacher, 2012).

Despite its high potential, however, the actual productivity of potatoes at the national level is very low (9 t/ha) (APHRD, 2009; CSA, 2014). The progress in the potato sector is also below expectation, mainly as a result of the shortage of clean and affordable seed tubers of improved

potato varieties coupled with poor agronomic practices such as improper planting density and dates, inadequate soil fertility management and disease control measures, and poor post-harvest management (Berga *et al.*, 1994; Mulatu *et al.*, 2005; Gildemacher *et al.*, 2009). The majority of farmers use farm-saved seed potatoes that build-up diseases - bacterial wilt and viruses - from several cropping cycles causing severe degeneration of planting material across generations (Berga *et al.*, 1994). For example, bacterial wilt (causing agent *Ralstonia solanacearum*) is increasingly becoming a serious threat to potato production in Ethiopia causing heavy crop losses. The main factors associated with bacterial wilt occurrence are the lack of well-developed seed systems that certify and regulate the distribution of good quality seed potato, lack of quality assurance in seed potato farmers, planting of susceptible potato varieties and poor pest management practices (Gorfu, Woldegiorgis and Kassa, 2013; Kassa, 2013). Bacterial wilt survives in both soil and seed, has a wide host range and spreads in many ways such as through planting materials, irrigation water, farm implements and vectors, which makes management of the disease very complex and demanding. Compared to other ways of transmission, seed tubers with latent infection provide the major path for bacterial wilt dissemination. Seed tubers harvested from polluted soils have the largest possibility of being infected and thus spread the disease that limits potato cultivation (Kassa, 2013).

Improved ware and seed potato storages reduce postharvest losses. Ware storage expand the period of potato availability for household consumption, while improved seed storage keeps the quality of seed potatoes through regulating physical, physiological and disease problems. The majority of the farmers, however, store their potatoes on the floors of their houses, in sacks or baskets, which results in losses up to 50% after harvest. Poor storage also negatively affects the quality of seed tubers and subsequent performance of the crop in the field. Lack or non-adoption of improved ware storages also leads to price fluctuation of potatoes; farmers sell their potatoes at low prices soon after harvesting (Bergel, 1980; Endale *et al.*, 2008).

Therefore, interventions introducing technologies for improved potato production should not only consider the availability of improved potato varieties and improved seed quality but must also respond to potato production and management constraints that determine potato productivity.

Research setting and context

This study was conducted in Chencha *wereda*, in the southern part of Ethiopia. Chencha is located predominantly in the high-altitude zones (>2500 m above sea level) with bi-modal rainfall: a *Belg* (the short rainy season from March to May) and a *Meher* (the long rainy season from June to October) season. Agriculture dominates the farmers' livelihood strategies in the area with potato, enset (*Ensete ventricosum*), barley (*Hordeum vulgare*) and wheat (*Triticum aestivum*) as main staple crops and apple (*Malus* spp.) as an important cash crop (Mazengia *et al.*, 2015; Dersseh *et al.* 2016).

During the last five years, Vita has introduced potato technologies in Chencha *wereda*. Vita is a non-governmental organization founded in Ireland in 1989 to provide support to refugees. The focus of Vita turned to agriculture starting in 2005. Within Vita, development activities fall within four sectors: crop and livestock; soil fertility and environmental rehabilitation; fair price market; and water and finance (Vita, 2011). Starting in 2010, the introduction of improved potato technologies has become the major, highly visible component of Vita's agricultural development programming in southern Ethiopia. The technologies promoted in Chencha represented a combination of improved seed potatoes, agronomic field and storage practices, which are expected to improve the availability of quality seed and potato yield, and thereby income and food security of smallholding farmers.

This study was part of a research-based development programme implemented with the technical and financial support of Vita, the Irish Agriculture and Food Development Authority (Teagasc) and Wageningen University and Research. The programme involved three PhDs who worked closely together and were analysing, at least partly, the same farmers for different aspects of the potato sector. The programme focused on technological aspects of seed potato, the sustainability of farming systems in which potato is grown and the social dynamics of interventions introducing new potato technologies. The purpose of this programme is to improve: physiological age and potato seed tuber health, the agronomy and farm management of the farms, and understanding of technology adoption, diffusion and targeting of development interventions.

Research methods, tools of data collection and analysis

Field work was undertaken for more than 2.5 years (2013-2015). The primary units of assessment were potato growing households. Other units of assessment were seed potato cooperatives. The field work relied on interviews, household surveys and field observations.

In-depth interviews were held on (1) farmers' reasons for applying, or not applying, certain potato production practices, (2) farmer-to-farmer seed potato sharing practices, and (3) seed production and marketing via cooperatives, to analyse farmers' decision making processes, seed potato diffusion and seed cooperatives performances. In addition, key informants (individual) and seed cooperatives management and inspection committees (group basis) were interviewed to gather a complete picture of the establishment and operation of farmer cooperative groups.

An individual household survey was carried out to assess the way farmers produce potato and to analyse the changes farmers have experienced in cropping practices, asset holding and consumption pattern following the introduction and promotion of new potato production practices.

Direct field observations on how farmers crop potato and on bacterial wilt occurrence were also part of the tools used for data collection. The field observations were followed by informal discussions on the reasons why farmers crop, or don't crop, potato in a specific way (2013) and on bacterial wilt management efforts (2015).

The data processing consisted of transcription, identifying themes and core events, statistical and systematic analyses and interpretation. Point score analysis and mapping were also part of the data analysis using SPSS version 22®, Microsoft® Excel® and Node® Excel®. A more detailed description of methods for data collection and analysis is provided in the methods section of each chapter.

Layout of the thesis

The thesis is organised in six chapters including this general introductory chapter, which presents the research rationale, context and objectives, and the general methodological orientation. This section presents the contents of Chapters 2 through 6.

Chapter 2 provides a contextual analysis of potato production practices. In this chapter, I study the variation in the way farmers crop their potatoes. The chapter highlights that farmers' adoption decisions are influenced by access to potato technologies and availability of farm resources necessary for making the technologies workable.

Through mapping the seed flow, Chapter 3 traces the diffusion of seed tubers of new potato varieties in farmer networks. It analyses how social factors influence farmer-to-farmer sharing of improved seed potatoes. It also answers questions related to the terms and motivations for sharing seed and the amount of seed that was shared. This chapter shows that while the flow of improved potato varieties through farmer networks cross social barriers such as differences in wealth, gender and religion among farmers, there is a possibility of missing farmers who are not part of the seed networks: relatives, neighbours or friends of seed providers and farmers who face cash shortages.

The analysis of how farmers as a group cooperate to produce and market quality seed potato is presented in Chapter 4, by taking into account the social and material challenges of the processes of seed potato production and marketing. I found that interventions organizing seed cooperatives gave more attention to improving members' agronomic practices than building leaders' management skill. In reality, however, the process of producing and marketing quality seed potatoes is exposed to contextual challenges. For instance, the tensions between prescriptive rules, solidarity and individual interests influenced negatively the implementation of leaders' decisions and bacterial wilt causing heavy crop losses. As a result, quality seed potato production and marketing through cooperation and self-regulation could not be stable and durable.

Chapter 5 provides the impact of potato technologies at household level. The chapter is an analysis of the role of potato in building the livelihood of smallholder farmers. The impact depended first and foremost on the wealth category of the participating farmers. Introduction of potato technologies has a higher impact on the income and livelihood of wealthy participant farmers, compared to poor farmers. Farmers across wealth classes took different livelihood strategies: wealthier farmers improved their houses and livestock numbers whereas poor farmers invested mainly in petty trading. The possible indirect benefits from technologies introduced in the locality also impact mainly on wealthy farmers. In general, the positive effects of potato technologies at household level are conditional on the pre-existing farm resources and households' priorities.

The general discussion chapter (Chapter 6) pulls together and discusses the main results presented in the separate research chapters to address the main objectives of the study and answer the specific research questions. The chapter puts the results from potato production practices of smallholder farmers in the broader debates of interventions introducing technologies. Suggestions are provided for technology-oriented interventions to improve the adoption, diffusion and impact of agricultural technologies.

References

Adesina, A. A. and Zinnah, M.M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. Agricultural Economics 9: 297-311.

Adjei-Nsiah, S., Leeuwis, C., Giller, K.E. and Kuyper, T.W. (2008). Action research on alternative land tenure arrangements in Wenchi, Ghana: learning from ambiguous social dynamics and self-organized institutional innovation. Agricultural Human Values 25: 389-403.

Ajieh, P. C., Agwu, A. E. and Anyanwu, A. C. (2008). Constraints to privatization and commercialization of agricultural extension services as perceived by extension professionals and farmers. African Journal of Agricultural Research 3 (5): 343–347.

Anderson, J.R. (2007). Agricultural advisory services. A background paper for the world development report 2008. Washington, D.C.: World Bank.

Anderson, J.R. and Feder, G. (2007). Agricultural extension. In: R. Evenson and P. Pingali (Eds.), Agricultural development: farmers, farm production and farm markets. Handbook of agricultural economics. Amsterdam: Elsevier, 3: 2343–2378.

Andersson, J.A. and Giller, K.E. (2012). Chapter 2. On heretics and God's blanket salesmen: contested claims for conservation agriculture and the politics of its promotion in African smallholder farming. In: J. Sumberg and J. Thompson (Eds.), Contested agronomy: Agricultural research in a changing world. London: Earthscan, 22–46.

APHRD (Animal and Plant Health Regulatory Directorate) (2009). Crop variety register, Issue No. 12, June, 2009, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

Argarwal, B. (1983). Diffusion of rural innovations: some analytical issues and the case of wood burning stoves. World Development 11 (4): 359-376.

Bebbington, A. and Farrington, J. (1992). Private voluntary initiatives: enhancing the public sector's capacity to respond to non-governmental organization needs. In: J.R. Anderson and C. de Haan (Eds.), Public and private roles in agricultural development: proceedings of the Twelfth Agricultural Sector Symposium. The World Bank Washington, D.C, pp 223-248.

Byerlee, D., Spielman, D., Alemu, D. and Gautam, M. (2007). Policies to promote cereal intensification in Ethiopia: A review of evidence and experience. IFPRI Discussion Paper. 00707, IFPRI, Washington, DC.

Berga, L., Woldegiorgis, G., Terrisa, J., Bereke, T.T., and Yaynu, H. (1994). Potato improvement research. In: H. Edward and D. Lemma (Eds.), Proceedings of the second national horticultural workshop of Ethiopia. Addis Ababa, Ethiopia, pp. 19-23.

Bergel, H. (1980). Production, marketing and consumption of potatoes in the Ethiopian highlands. Centre for advanced training in agricultural development, Institute of Socio-Economics of Agricultural Development, Technical University of Berlin.

Beyene, H. (2008). Adoption of improved teff and wheat production in crop livestock mixed system in northern and western Shewa zones of Ethiopia. PhD Thesis, University of Pretoria, Pretoria.

Bratton, M. (1989). The politics of government-NGO relation in Africa. World Development 17 (4): 569-587.

Chambers, R. (1996). The primacy of the personal. In: E. Edwards and D. Hulme (Eds.), Beyond the magic bullet: NGO performance and accountability in the post-cold war world. West Hatford: Kumarian Press 241-253.

Chambers, R., Pacey, A.P. and Thrupp, L.R. (1989). Farmer first: Farmer innovation and agricultural research. London: IT technology publication. Ed.

Cromwell, E. (1993). Sowing beyond the state. Overseas development corporation, London.

CSA (2009). Agricultural sample survey: Report on area and production of crops, Addis Ababa, Ethiopia.

CSA (Central Statistical Agency). (2014). Agricultural sample survey report on area and production (private peasant holdings in Meher season). Addis Ababa: statistical bulletin.

Dadi, L., Burton, M. and Ozanne, A. (2004). Duration analysis of technological adoption in Ethiopian agriculture. Journal of Agricultural Economics 55 (3): 613-631.

Dinar, A. (1996). Extension commercialization: how much to charge for extension services. American Journal of Agricultural Economics 78 (1): 1-12.

Demo, P., Lemaga, B., Kakuhenzire, R., Schulz, S., Borus D., Barker, I., Woldegiorgis, G., Parker, M.L. and Schulte-Geldermann, E. (2015). Strategies to improve seed potato quality and supply in Sub-Saharan Africa: Experience from interventions in five countries. In: J. Low, M. Nyongesa, S. Quinn and M. Parker (Eds.), Potato and Sweet Potato in Africa: Transforming the value chains for food and nutrition security. CAB International: London, UK, pp. 155-166

Dersseh, W.M., Gebresilase, Y. T., Schulte, R.P.O. and Struik, P.C. (2016). The analysis of potato farming systems in Chencha, Ethiopia: Input, output and constraints. American Journal of Potato Research 93: 436-447. DOI 10.1007/s12230-016-9521-9.

Dollar, D. and Svensson, J. (2000). What explains the success or failure of structural adjustment programmes? The Economic Journal 110(466): 894-917.

Eicher, C.K. (1989). Sustainable institutions for African agricultural development. Working paper No. 19. The Hague: ISNAR.

Endale, G., Gebremedhin, W., Bekele, K., and Lemaga, B. (2008). Post-harvest management. In: W. Gebremedhin, G. Endale, and B. Lemaga (Eds.), Root and tuber crops: The untapped resources. Addis Abeba: Ethiopian Institute of Agricultural Research, pp. 113-130.

FAO (2008). International Year of the Potato. Retrieved 02/06/16 from http://www.potato 2008.org.

FAO (2012). Smallholders and family farmers. Food and agriculture organization of the United Nations. Retrieved 12/09/16 from: http://www.fao.org/fileadmin/templates/nr/sustainability_pathways/docs/Factsheet

Farrington, J. (1995). The changing public role in agricultural extension. Food Policy 20(6): 537-544.

Feder, G., Willett, A. and Zijp, W. (2001). Agricultural extension: generic challenges and the ingredients for solutions. In: S. Wolf and D. Zilberman (Eds.), Knowledge generation and technical change: institutional innovation in agriculture. Boston, Mass.: Kluwer.

Feder, G., Just, R. and Zilberman, D. (1985). Adoption of agricultural innovations in developing countries: a survey. Economic Development and Cultural Change 33:255–97.

Fowler, A. and Biekart, K. (1996). Do private agencies really make a difference? In: D. Sogge, (ed.), Compassion and calculation: the business of private foreign aid, 107-135, Transnational Institute/Pluto Press, Amsterdam/London.

Gabre-Mahdin, E. and Haggblade, S. (2004). Successes in African agriculture: results of an expert survey. World Development 32 (5): 745–766.

Gebremedhin, B. and Jaleta, M. (2010). Commercialization of smallholders: does market orientation translate into market participation? Improving productivity and market success (IPMS) of Ethiopian farmers project Working Paper 22. Nairobi, Kenya, ILRI.

Gildemacher, P.R., Kaguongo, W., Ortiz, O, . Tesfaye, A., G. Woldegiorgis, G., Wagoire, W., Kakuhenzire, R., Kinyae, P.M., Nyongesa, M., Struik, P.C. and Leewis, C. (2009).

Improving potato production in Kenya, Uganda and Ethiopia: A system diagnosis. Potato Research 52: 173–205.

Gildemacher, P.R. (2012). Innovation in seed potato systems in Eastern Africa. PhD thesis, Wageningen University, Wageningen, Netherlands.

Giller, K.E., Rowe, E.C., de Ridder, N. and van Keulen, H. (2006). Resource use dynamics and interactions in the tropics: Scaling up in space and time. Agricultural Systems, 88: 8–27.

Glover, D., Sumberg, J. and Andersson, J.A. (2016). The adoption problem; or why we still understand so little about technological change in African agriculture. Outlook on Agriculture, 45(1): 3-6.

Gollin, D. (2014). Smallholder agriculture in Africa: an overview and implications for policy. IIED Working Paper, IIED, London.

Gorfu, D., Woldegiorgis, G. and Kassa, B. (2013). Bacterial wilt: an emerging threat to Ethiopian potato industry. In: G. Woldegiorgis, S. Schulz and B. Berihun (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 211-222.

Haverkort, A.J., Woldegiorgis, G., van Koesveld, M.J., Ntizo, S., Wustman, R. and Zhang, X. (2015). On the road to potato processing in African tropical highlands. In: J. Low, M. Nyongesa, S. Quinn and M. Parker M. (Eds.), Potato and sweet potato in Africa: Transforming the value chains for food and nutrition security. CAB International: London, UK, pp. 435-452.

Hirpa, A., Meuwissen, M.P.M., van der Lans, I.A., Lommen, W.J.M., Oude Lansink, A.G.J.M., Tsegaye, A. and Struik, P.C. (2012). Farmers' opinion on seed potato management attributes in Ethiopia: A conjoint analysis. Agronomy Journal 104:1413–1424.

Horton, D. (1987). Potatoes: production, marketing and programs for developing countries. Westview Press, Colorado.

IFAD AND UNEP (2013). Smallholders, food security, and the environment (Rome). Retrieved 15/09/16 from http://www.ifad.org/climate/resources/smallholders.

Kaimowitz, D. (1993). The role of non-governmental organizations in agricultural research and technology transfer in Latin America. World Development 21(7): 1139-1150.

Kassa, B. (2013). Control of bacterial wilt and blackleg of potato using effective microorganisms. In: G. Woldegiorgis, S. Schulz, and B. Berihun (Eds.), Seed potato

tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 223-232.

Kcbede, Y., Gunjal, K. and Coffin, G. (1990). Adoption of new technologies in Ethiopian agriculture: the case of Tegulct-Bulga District, Shoa Province. Agricultural Economics, 4: 27-43.

Lipton. M. (1988). The place of agricultural research in the development of sub-Saharan Africa. World Development 16 (10): 1231-57.

Mazengia, W., Schulte, R., Tadese, Y., Griffin, D, Schulz, S. and Struik, P.C. (2016). The farming systems of potential potato production areas of Chencha, Southern Ethiopia. In: J. Low, M. Nyongesa, S. Quinn, and M. Parker (Eds.), Potato and sweet potato in Africa: Transforming the value chains for food and nutrition security. CAB International: London, UK, pp. 382-396.

Meijer, S.S., Catacutan, D., Ajayi, O.C., Sileshi, G.W. and Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability 13(1): 40-54.

Mulatu, E, Ibrahim, E.O. and Bekele, E. (2005). Improving potato seed tuber quality and producers' livelihoods in Hararghe, Eastern Ethiopia. Journal of New Seeds 7(3): 31-56.

Mercer, C. (1999). Reconceptualizing state-society relations in Tanzania: are NGOs 'making a difference'? Area 31(3): 247-258.

Nkonya, E., Schroeder, T. and Norman, D. (1990). Factors affecting adoption of improved maize seed and fertiliser in northern Tanzania. Journal of Agricultural Economics 48 (1): 1-12.Vita (2011). Programme statement of strategy, 2011-2015.

Reece, D. and Sumberg, J. (2003). More clients, less resources: toward a conceptual framework for agricultural research in marginal areas. Technovation 23: 409–421.

Richards, P. (1986). Coping with Hunger: Hazard and Experiment in an African Farming System. London: Allen and Unwin.

Riddell, J.B. (1992). Things fall apart again: structural adjustment programmes in sub-Saharan Africa. The Journal of Modern African Studies 30: 53-68

Röling, N.G. (1988). Extension science: information systems in agricultural development. Cambridge University Press, Cambridge.

Reutlinger, S. and van Holst Pellekaan, J. (1986). Poverty and hunger: issues and options for food security in developing countries. Washington: World Bank.

Rono, J.K. (2002). The impact of the structural adjustment programmes on Kenyan society. Journal of Society Development in Africa 17(1): 81-98.

De Steenhuijsen Piters, P.C.B. de (1995). Diversity of fields and farmers: Explaining yield variations in northern Cameroon, PhD thesis, Wageningen University, Wageningen.

Sumberg, J., Okali C. and Reece, D. (2003). Agricultural research in the face of diversity, local knowledge and the participation imperative: theoretical considerations. Agricultural Systems 76:739-753.

Sumberg, J., Gilbert, E. and Blackie, M. (2004). Income diversity, technology choice and agricultural research policy in sub-Saharan Africa. Development Policy Review 22 (2): 131-146..

Tesfaye, A., Woldegiorgis, G. and Kaguongo, W (2013). Adoption and impact of potato production technologies in Oromiya and Amhara regions. In: G. Woldegiorgis, S. Schulz, and B. Berihun (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 256-278.

Van der Ploeg, J. D. (1994). Styles of farming: an introductory note on concepts and methodology. Part I: The practice of endogenous development. In: J.D. van der Ploeg, A. Long (Eds.), Born from within. Practice and perspectives of endogenous rural development. Assen, Van Gorkum, pp. 7 - 31.

Vivian, J. and Maseko, G. (1994). NGOs, participation and rural development: testing the assumption with evidence from Zimbabwe. New York. United Nations Research Institute for Development.

Walker, S.T. and Alwang, J. (2015). The importance of generating and documenting varietal change in sub-Sharan Africa. In: S.T. Walker and J. Alwang (Eds.), Crop improvement, adoption and impact of improved varieties in food crops in sub-Sharan Africa. CGIAR and CAB International, UK and USA, 1-6.

Wiggins, S. and Cromwell, E. (1995). NGOs and seed provision to smallholders in developing countries. World Development 23(3): 413-422.

Woldegiorgis, G., Gebre, E. and Lemaga, B. (2008). Potato variety development. In: W. Gebremedhin, G. Endale and B. Lemaga. (Eds.), Root and tuber crops: The untapped resources. Addis Abeba: Ethiopian Institute of Agricultural Research, pp. 15-32.

Woldegiorgis, G., Hailemariam, G., Lemaga, B. and Schulz, S. (2015). Quality seed potato production: Experiences from the Highlands of Ethiopia. In: J. Low, M. Nyongesa, S. Quinn and M. Parker (Eds.), Potato and Sweet Potato in Africa: Transforming the value chains for food and nutrition security. CAB International: London, UK, pp. 186-198.

World Bank. (2007). World Development Report 2008: Agriculture for Development. Washington, DC.

CHAPTER 2

Understanding farmers' potato production practices and use of improved varieties in Chencha, Ethiopia

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Abstract

This study was carried out to better understand non-adoption of improved varieties of potato (*Solanum tuberosum*) and associated technologies by smallholder farmers in Chencha, Ethiopia. Data were collected through a survey (n=47) and in-depth interviews (n=20). It shows how wealth status was a factor of major importance. Most wealthy and some medium-wealthy farmers adopted improved potato varieties and many of the improved production practices; they had access to seed, associated knowledge and support, and sufficient resources that were necessary to apply the improved practices. Non-adoption was common among many medium-wealthy and most poor farmers: they lacked – next to access to the technologies and knowledge – cash, land and labor. Results indicated the need to re-think research and intervention efforts. Next to paying attention to differences in the access to technology and the related knowledge, there is a need to consider the variation in technology needs, supporting micro-credit services, and room to experiment. As a result, different combinations of improved production practices may be adopted.

Introduction

A major problem in Ethiopia, and in Africa as a whole, is the low productivity of the important staple crops, which leads to food insecurity for rural households and a national dependence on food imports (Byerlee *et al.*, 2007; Wale and Yalew 2007). Many improved varieties are poorly adopted by smallholder farmers, despite their potential to increase productivity (Walker and Alwang, 2015). The case of potato grown in the densely populated midlands and highlands of Ethiopia represents an example. In these areas, potato has become an important food and cash crop for smallholder farmers (Gildemacher *et al.*, 2009; Hirpa *et al.*, 2012; Woldegiorgis *et al.*, 2013). To realize the potential of the crop for the local and national food security, the Ethiopian government started a potato research program as early as 1975 (Woldegiorgis *et al.*, 2008a). During the last two decades, nine improved potato varieties have been introduced to smallholder farmers, along with improved crop management practices (Tesfaye *et al.*, 2013). However, the majority of the farmers still continue to grow old potato varieties (Mulatu *et al.*, 2005; CSA, 2011; Kolech *et al.*, 2015; Labarta, 2015) and use traditional crop management practices (Woldegiorgis *et al.*, 2008b; Berihun and Woldegiorgis, 2013).

Studies have been conducted to better understand the poor adoption of new potato production technologies and to suggest pathways towards improving productivity. These studies point to a range of constraints. Some studies highlighted the limited availability of high-quality seed tubers (Woldegiorgis *et al.*, 2008a; Hirpa *et al.*, 2010). Limenih *et al.* (2013) found that education of the household head, access to extension services, farmers' preference of specific traits (yield, price and maturity type), and the availability of land, cash, livestock and labor were positively correlated with technology adoption. Hirpa *et al.* (2012) noted that newly released potato varieties were introduced with standard recommendations on production practices without considering farmers' conditions. It was also argued that new varieties with favorable consumption and market-quality characteristics and improved farmers' access to information could enhance adoption of improved potato varieties (Abebe *et al.*, 2013; Kolech et al., 2015). These studies, though helpful, had some weaknesses. Like in studies on other crops (Pircher *et al.*, 2012), the correlations found in these studies did not explain the motivations of farmers to reject particular improved technologies. In addition, most of these studies were not explicit about their underlying assumptions in relation to adoption but were most likely based on Rogers' diffusion theory (Rogers, 2003). This theory assumes that the

non-adopters are farmers who will eventually adopt. Thus, they offered little concrete guidance on more effective support to increase farmers' potato productivity. The objectives of the research reported in this paper, therefore, were: (1) to explore the variation in farmers' current potato production practices, and (2) to identify factors that explain the variation in technology adoption. We describe a case study in an area with high potato production potential in Ethiopia. By analyzing socially differentiated data on variety use and crop production practices, we are able to explain the observed adoption of improved production practices. We discuss the findings in the context of designing more effective interventions for the introduction of improved crop varieties and production practices for smallholder farmers in Africa.

Methods

Research context, farmer selection and data collection

Fieldwork for this study was carried out between January and June 2013 in four *kebeles*[1] with suitable potato production conditions in Chencha *wereda*, Gamo Gofa Zone, Southern Nations, Nationalities and Peoples Regional State, Ethiopia (Table 2.1). Approximately 80% of the Chencha *wereda* belongs to highland agro-ecology (>2500 m above sea level), whereas the remainder 20% is midland (2000-2500 m above sea level). Agriculture in Chencha is primarily rain-fed and there are two cropping seasons: the short *Belg* (March to May) season and the longer *Meher* (June to October) season. In this area, potato is equally important in both seasons. Next to potato, farmers grow enset (*Ensete ventricosum*), barley and wheat as main staple crops. Apple is an important cash crop and vegetables are used for home consumption and commercialized for cash (Dersseh *et al.*, 2016). During the last 10 years, Non-Governmental Organizations (NGOs) disseminated various improved potato varieties (Gudene, Jalene, Tolecha, Wechecha, and Degemegn) in the region, in combination with improved production technologies.

We surveyed 47 farmers to collect information on their potato-farming practices. To select these 47 farmers, we applied random sampling using farmers' lists of names registered by each *kebele* administration. We also categorized the selected farmers on the basis of a participatory wealth ranking by a group of local administrator and farmers' representatives:

[1] *Kebele* is the smallest administrative unit, and *Wereda* is the one immediately above it.

Table 2.1. Characteristics of study sites, surveyed farmers (n=47) and their farms

Characteristics	*Kebele*			
	Yoyera	Doko Losha	Laka	Gendo Gembella
Number of households [a]	370	407	306	273
Elevation (m above sea level)[b]	2600	2749	2578	2640
Number of survey respondents	12	14	12	9
% of wealthy farmers among respondents	33	14	4	55
% of women among respondents	16	7	41	33
Average age of respondents (year)	45	53	36	36
Average household size	8	7	5	5
Average number of school years	4	4	5	5
Average farm size (ha)	0.82	0.69	1.00	1.20
Average number of plots	5	10	8	12
Number of old varieties [c]	2	2	2	2
Number of new varieties	5	4	4	6

[a] Data from personal communication of local administrators, [b] Dersseh *et al*. (2016), [c] Based on variety names

15 farmers were identified as (relatively) wealthy, 18 as medium-wealthy and 14 as poor. Farmers, who were categorized by local people as relatively wealthy, had more than 1 ha of land, 3-4 oxen, several cows and sheep, at least five houses with corrugated sheets and more than 300 enset trees (for details, see Tadesse *et al.*, 2016). As the survey meant to provide descriptive statistics only, we refrained from further statistically testing these wealth-ranking results.

To better understand farmers' reasons for applying or not applying certain practices, we held in-depth interviews, in combination with field observations and a questionnaire, with 20 of these 47 potato farmers. We selected these 20 farmers randomly, until data saturation was reached: 7 were (relatively) wealthy, 9 medium-wealthy and 4 poor. Of the 20, 12 were men and 8 were women. During interviews, we used support of translators upon request. The results of these in-depth interviews are summarized in Tables 2.4-2.7.

Data analysis

Reasons for farmers to adopt or reject a particular potato technology and the importance of these reasons were assessed through point-score analysis, a methodology developed for studying the decision-making process in agriculture (Beckford, 2002; Ilbery, 1977). For setting up the modified point-score analysis; first, three in-depth interviews were held (one

farmer from each wealth category) to make an inventory of farmers' reasons. This information was then used to develop a questionnaire that was used during the 20 in-depth interviews. The importance of each of the reasons was defined by the farmers, assigning a weight to the reasons: essential (=3), important (=2), relevant (=1), and not relevant (=0). From this, we calculated for each reason, on the basis of the farmers' responses, 1) a potential maximum score (PMS) and 2) a realized total score. The percentage of the realized total score was calculated for each wealth category. When farmers mentioned a reason not indicated in the questionnaire, the reason was added to the list.

The first author translated the transcripts of the in-depth interviews from Amharic into English. Subsequently, the transcripts passed through systematic analysis: first and second level coding and interpretation (Creswell, 2009). The findings were further analyzed using descriptive statistics, including percentages and maximum scores, with the support of point-score analysis (Ilbery, 1977) using Microsoft® Excel®. We did not apply further statistical analysis on the survey data because of the exploratory character of the study: we were, in the first place, interested in the explanations behind the adoption pattern.

Results

Initial seed potato source

Data from the questionnaire showed that a farmer was growing one to five potato varieties, with an average of 2.3 potato varieties per farm. Most wealthy (93%), the majority of medium-wealthy (84%) and only a few of the poor farmers (38%) planted new improved potato varieties (i.e., varieties introduced within the last 10 years). All but two wealthy farmers grew old potato varieties (i.e., improved varieties introduced 20 to 30 years ago). Approximately 80% of all farmers recalled acquiring their first seed lot of their old varieties from the local markets, the other 20% reported it came from a friend or relative (Table 2.2). For the new varieties, the dominant source among wealthy households was the NGOs (73%), whereas most medium-wealthy and poor farmers mentioned other sources, i.e., the market, friends and relatives. The resource-poor farmers explained that potato seed from formal sources was very costly and difficult to get. One of the farmers explained:

> "To get seed of new potatoes from the institutions, there are requirements I am expected to fulfil, such as having enough land to plant the amount of seed

provided and cash for purchasing the recommended amount of synthetic fertilizers. I have neither the cash nor the required area of land. I am therefore not entitled to get the seed."

Table 2.2. Initial sources for seed tubers used by the farmers for the new varieties (n=36) and of the old varieties (n=46), disaggregated by wealth category

Initial seed source	% of respondents			
	Total	Wealthy (n=15)	Medium (n=16)	Poor (n=5)
New varieties				
Institutions	47	73	31	20
Other sources [a]	53	27	69	80
Old varieties [b]		(n=14)	(n=19)	(n=13)
Local markets	78	79	74	85
Other farmers	22	21	26	15

[a] Seed cooperatives, local market and other famers (relatives, friends, neighbours, and acquaintance), [b] One farmer did not grow old variety

Management of fields and soils for growing potato

Farmers preferred to plant new potato varieties in fertile soil types ('*Gobo'* and '*Modo'*) and in plots near their home to facilitate monitoring of pest and disease incidences, timely application of chemicals and to reduce the cost of transportation of seed tubers and harvest potatoes. Old varieties were most commonly planted in less fertile soils because farmers believed that these varieties were adapted to these soils. One farmer mentioned that she preferred to plant potato for consumption in a soil with low water-holding capacity ('*Kalta')* "to facilitate early harvesting after maturity." Seventy percent of the farmers preferred not to intercrop the new potato varieties with *'amochi'* (i.e., a local tuber crop, *Arisaema schimperianum* Schott) to avoid potato yield loss; the other 30% of respondents intercropped the potatoes with *'amochi'* for efficient use of land.

Farmers planted potato both in the *Belg* (short rain) season and the *Meher* (long rain) season. With respect to crop rotation, in the Belg season, the dominant practice for planting new and old varieties was after having harvested wheat in fore-going season. Some wealthy farmers planted *Belg* potatoes after harvesting legumes, bean or pea, to benefit from the soil nitrogen fixed by these legumes. Farmers planted potatoes in the *Meher* season after fallow or after *Belg*-grown barley. In both cropping seasons, across the wealth classes, planting potato after potato was practised more often (but not exclusively) for old varieties than for new varieties.

Land preparation and later cultivation

The land was prepared manually, typically with hoes (70%) or with oxen (30%), mainly using family labor. In the Yoyera *kebele,* oxen traction was not used because of the mountainous topography, the small size of the plots, and forage scarcity. Extension workers advise to plow at least three times to get a fine soil for planting new seed potatoes. However, in the 2013 *Belg* season, only medium-wealthy and wealthy farmers, who were engaged in seed potato production tilled their land three times. They explained that they had received advice, practical training and had seen the yield difference in exposure visits to other farmers' fields. Poor farmers tilled their land less frequently before planting than the medium-wealthy and wealthy households (Table 2.3), mainly because of competition for labor with the tillage of land for other cereal crops, and they could not afford to hire additional labor.

After planting improved potato varieties in 2013, many of the wealthy (67%) and medium-wealthy (63%) households practised shallow tillage three more times. The poor farmers (80%) cultivated their improved potatoes less frequently than wealthy and medium-wealthy farmers (Table 2.3). All wealthy farmers carried out the first round of tillage 3-4 weeks after planting, whereas all medium-wealthy and poor farmers did so 4-5 weeks after planting. The wealthy farmers with better access to institutional support (training and inputs) reported that planting high-yielding seed potato that was properly stored and sprouted, and using an appropriate amount of fertilizer, facilitated early cultivation.

Planting material

For improved varieties (both old and new varieties), all poor and medium-wealthy farmers planted small (*'hen's egg sized'*) tubers, whereas 71% of wealthy farmers planted a mixture of small and medium-sized seed tubers. Lower cost of seed tubers was the main reason for planting small potatoes (Table 2.4). One of the wealthy farmers explained:

> "In the training by the *Wereda* Office of Agriculture, I learned that planting medium-sized tubers was the best. But, this means that I would not have enough tubers for all the land I want to plant with potatoes. Using small tubers, I can plant more plots."

Other reasons are that medium- and large-sized tubers are preferred for the market and household consumption. Some farmers said that the small-sized seed potato also produced large numbers of tubers of good size when appropriately managed and fertilized. In addition,

Table 2.3. Potato production practices in new varieties grown in the 2013 *Belg* season by farmers of different wealth categories

Production practices		% of respondents (n=36)[b]		
		Wealthy (n=15)	Medium (n=16)	Poor (n=5)
Tillage frequency (land preparation)	One time	0	13	40
	Two times	47	63	60
	Three times	53	25	0
Planting	Ridge	80	63	20
	Flat soil	20	38	80
Fertility management	Synthetic only	47	44	20
	FYM [a] only	0	6	40
	Combination	53	50	40
Later cultivation	One time	0	6	20
	Two times	33	31	80
	Three times	67	63	0
Harvesting	Piecemeal only	0	6	60
	Once only	33	25	20
	Combination	67	69	20
Seed storage	Diffuse-light storage	73	32	20
	Bag or corner of a room	27	68	80

[a] Farm yard manure, [b] Out of 47 farmers 11 did not grow new potato varieties and did not apply the associated management practices

Table 2.4. Reasons and their importance for planting small-sized seed tubers for farmers of different wealth groups

Reasons	Total score (PMS=45)*	% of total score		
		Wealthy (n=2)	Medium (n=9)	Poor (n=4)
Cost or amount of seed tubers	39	100	81	92
Consumption and market preference	34	83	74	75
Small-sized tubers perform equally well	24	50	52	58
Family tradition	6	-	7	33

*PMS = Possible maximum score

some of the poor and one of medium-wealthy farmers said they planted small tubers because that was what their parents had been doing.

Potato planting

The survey data showed that 80% of the wealthy and 63% of medium-wealthy farmers planted their new potato varieties on ridges, whereas the majority of poor farmers (80%)

planted new varieties in flat soil (Table 2.3). Across wealth groups, farmers planted the old varieties without ridging: old varieties have long stolons that would grow out of the ridges; this would reduce yield and expose the tubers to light.

Farmers who planted on ridges explained that they did this because it improved yield, eased weeding, hilling up and regular field inspection, and it made harvesting easier. At the same time, wealthy and medium-wealthy farmers with knowledge and/or experience of ridge planting, pointed to the labor requirement as the most important reason for not adopting it (Table 2.5). The planting on ridges and hilling implies tilling the land at least four times. Planting is also laborious and can usually not be done with family labor only. Employing additional persons and providing them with lunches proves expensive (€ 1.30 or $1.35 per person per day). There were also wealthy and medium-wealthy farmers who considered that ridging reduced land-use efficiency because the furrows between the ridges require extra space. Some farmers, mainly poor ones, said they did not hill because they were not aware of the details of the practice.

Soil fertility management

During the 2013 *Belg* season, some of the wealthy (47%) and medium-wealthy (44%) farmers applied only synthetic fertilizers, whereas one single poor farmer, who planted improved varieties, did so (Table 2.3). The rest of the farmers applied either a combination of organic and synthetic fertilizers or farm yard manure only. For old varieties, all except one wealthy farmer applied manure in combination with synthetic fertilizer. About 80% of the farmers preferred manure over synthetic fertilizers, but they appreciated synthetic fertilizer for its positive effect on yield and the ease of transportation.

Farmers applied less amount of synthetic fertilizers than the doses recommended by extension workers, principally because of the high costs (Table 2.6). Manure improves potato yield with minimal cash requirement and all farmers have cattle and/or sheep. The wealthy farmers mentioned shortage of manure as an important reason for also using synthetic fertilizer. They prioritized manure application for apple and *enset* crops. In all three wealth groups, farmers also considered the combined application of manure and synthetic fertilizer important because synthetic fertilizer on its own rendered soil structure hard and less fertile.

Table 2.5. Reasons and their importance for farmers not to plant potato in ridges

Reasons	Total score (PMS =60)*	% of total score		
		Wealthy (n=7)	Medium (n=9)	Poor (n=4)
Labour demanding	45	81	85	42
Land use efficiency	27	57	56	0
Do not know about the practice	15	5	15	83
Potato variety	8	10	21	0

*PMS = Possible maximum score

Table 2.6. Reasons and their importance for farmers to combine synthetic and organic fertilizers

Reasons	Total score (PMS =48)*	% of total score		
		Wealthy (n=6)	Medium (n=8)	Poor (n=2)
Costs of synthetic fertilizers	44	83	96	100
Shortage of manure	29	72	58	33
Keep soil fertility	30	67	63	50
Not to have a dependent soil	18	56	25	33

*PMS = Possible maximum score

Another reason that farmers pointed out was that once synthetic fertilizers were applied alone, the soil demands continuous fertilization to produce acceptable crop yields: "the soil becomes dependent on synthetic fertilizer," we heard farmers saying.

Disease management

Most respondents (32 of 36) did not apply crop protection chemicals. The most important reason was that respondents lacked knowledge about the use of such chemicals. Some of the wealthy (38%) and medium-wealthy (44%) farmers could not tell which chemical was appropriate for what kind of disease. None of the poor farmers had knowledge about chemicals for use in potato production. Secondly, four out of 15 wealthy farmers, and five out of 16 medium-wealthy farmers reported that chemicals were expensive. Finally, a reason for not using chemicals when they should be applied, i.e. when disease incidence required, was the restricted availability in agro-chemical shops.

To combat bacterial wilt (*Ralstonia solanacearum*) in potato, extension workers promoted planting clean seed, planting a less susceptible variety, and applying crop rotation. Farmers in this study used crop rotation as the dominant strategy. In the in-depth interviews, only two of the wealthy and one of the medium-wealthy farmers said that they applied the recommended

interval between two subsequent potato crops planted on their plot, i.e. six cropping seasons (corresponding to 3 years). They said to have learned this from the extension agents and other projects advocating the practice and benefits of crop rotation. The majority of the wealthy (57%) and many of the medium-wealthy (43%) farmers said that they applied a two-season interval between two subsequent potato crops, whereas most of the poor farmers (75%) practised a one-season interval. The most important reason for not following the rotation advice was a lack of adequate information among the majority of the wealthy (73%), medium-wealthy (67%) and poor (75%) farmers. When asked, these farmers could not explain how rotation would mitigate wilting. Shortage of land was the second most important reason mentioned mostly by medium-wealthy (63%) and poor (92%) farmers. Many of the wealthy (60%) and medium-wealthy (58%) farmers also mentioned plot distance as a factor: some of their plots were found at 2-4 hours walking distance from home. These remote plots were also highly subjected to mole rat and porcupine damage: they would have to be guarded during harvest time. As a consequence, potato was not part of the crop rotation in such plots, but more frequently grown closer to home.

Harvesting

To determine harvesting time, farmers waited until the color of foliage turned yellow. Some farmers would also dig up a 'test' hill. Only five wealthy and four medium-wealthy farmers harvested all their potatoes at once (Table 2.3). The majority of the wealthy and medium-wealthy farmers combined piecemeal harvesting with harvesting all at once for plantings with different purposes (i.e., for home consumption and the market, respectively), whereas piecemeal harvesting was the dominant practice among poor farmers. From the in-depth interviews, we learned that the most important reason given by wealthy and medium-wealthy farmers to harvest piecemeal was labor shortage (Table 2.7). Minimizing losses was another reason to harvest piecemeal, which is associated with lack of proper storage facilities. Unharvested potatoes remain fresh for longer, compared with when they are kept in the traditional storages. The most important reason for the poor farmers to harvest piecemeal was the fact that when they only harvest potatoes when needed, usually for home consumption, it helps them to stretch the availability across a longer time period. They said that this practice actually reduced the amount and the frequency with which they consumed potatoes.

Post-harvest management

Farmers said that after harvesting, they transported the tubers to their homes, and spread them in front of their house or in the corner of a room to give the skin time to harden. The sorting and storing practices differed among farmers of different wealth groups. The wealthy and medium-wealthy farmers, who owned a diffuse-light storage facility (DLS) (73% and 32%, respectively, constructed with financial support of NGOs), selected their small and medium-sized tubers to be stored as seed, and large-sized tubers for consumption and marketing purposes (Table 2.3). Sorting, however, was not part of the post-harvest practice of many of the medium-wealthy and the majority of poor farmers: they stored their ware and seed potatoes together in bags or kept them in heaps in corners of the main room of the traditional house.

Farmers with DLS reported that their seed storage had many benefits, including the development of short and sturdy green sprouts on the tubers, which facilitated uniform emergence. The most important reason for some of the wealthy farmers not to store their seed in DLS was that they had only recently become aware of the technology (Table 2.8). The most important reason for the medium-wealthy and some of the poor farmers was the costs of the construction material, i.e., mainly wood and a corrugated iron roof. For a considerable section of the poor farmers, the most important reason was that they were not aware of the DLS technology and its benefits. In addition, the amount of seed to store was so small for some medium-wealthy and poor farmers that they did not see the reason to adopt an expensive technology, which, they said, was designed for large amounts of seed potato.

Table 2.7. Reasons and their importance for farmers given to harvest their potatoes 'piecemeal'

Factors	Total score (PMS=45) *	% of total score		
		Wealthy (n=4)	Medium (n=7)	Poor (n=4)
Labour shortage	31	92	76	33
Minimizing post-harvest loss	27	58	67	50
Extending potato availability	22	33	38	83

* PMS = Possible maximum score

Table 2.8. Reasons and their importance for farmers not to store their seed in a diffuse-light store

Reasons	Total score (PMS=36)*	% of total score		
		Wealthy (n=2)	Medium (n=6)	Poor (n=4)
Only recently informed	12	67	33	25
Expensive	22	33	78	50
Amount of seed	15	0	44	58
Lack of awareness	10	0	17	58

*PMS = Possible maximum score.

Discussion

The data from the survey and in-depth interviews showed that the adoption of improved potato varieties was highest among relatively wealthy farmers. The adoption of improved production practices showed a similar pattern, pointing to a strong association between farmers' wealth status and the use of improved varieties and improved production practices. This association is explained by two factors that strongly influenced the adoption of introduced improved potato technologies: 1) access to the seeds of improved varieties, and the associated support and information; and 2) the availability of resources that were needed to apply the improved practices.

Access to technologies and knowledge was a fundamental factor in understanding the adoption of improved varieties and practices among the majority of wealthy and some of the medium-wealthy farmers. In most cases, these farmers had first-hand access to seed, support for the construction of diffuse-light stores and knowledge from the development agencies, because they had been participating in demonstration and training activities. By contrast, most of the poor farmers could not explain the improved practices, such as planting on ridges, improved storage practices and crop rotation, simply because they were not aware of these practices.

Adoption was also related to the availability of resources (land, labor and cash) that are necessary to reap benefits from the improved technology. Notably, labor-constraint was cited as a reason by some of the wealthy and medium-wealthy farmers for not tilling as frequently as recommended, not planting on ridges or not harvesting at once. Cash facilitated the hiring of labor for some wealthy and medium-wealthy farmers, but was apparently still an important constraint across wealth groups in deciding which seed tubers size to plant, whether or not to construct a DLS, and the extent to which to make use of synthetic fertilizers. In the definition

of crop rotation, the availability of land, which was further limited by the unsuitability of far-away fields for potato production (they were vulnerable to damage by rodents and implied high transportation costs), was an important decision factor. The fact that the majority of the farmers rejected or only partially adopted the improved varieties and practices (all except two wealthy farmers were still planting one or two old varieties) indicated that the traditional technology, the planting of local varieties without ridging and without much inputs, was still relevant for farmers of all wealth groups.

Summarizing, the findings showed that, overall, farmers faced diverse constraints to the adoption of improved potato production practices, mainly determined by the access to knowledge, labor, land, and cash. These findings align with other studies that showed that lack of access to seed and information formed important constraints to improving crop production in Eastern Africa (Pircher *et al.*, 2014; Limenih *et al.*, 2013; Schulte-Geldermann, 2013). Also, the biased targeting of better-off farmers by the extension system as an explanation for the high adoption among wealthy farmers has been reported earlier in the context of chickpea seed in Ethiopia and improved technologies in rural Mozambique (e.g., Asfaw *et al.*, 2011; Cunguara and Moder 2011). The direct contact between the extension workers during training and demonstration activities helped farmers to know how to manage these new technologies and reduce the uncertainty about their performance (Khalil Haque and Hoque, 2014). Our study further showed that because of differences in resource endowment, farmers' technology preferences in a community were not uniform, and differed according to the level of knowledge and assets a household possessed. This made the improved potato technology beyond the reach of the poor farmers.

Conclusions

In general, most adoption studies dealing with improved agricultural technologies (e.g., seed, crop and soil management practices) yield insights based on correlations between variables. Many of these studies indicate that less farm resources, lower farmers' education and economic status are related to lower adoption, but seldom do they explain underlying rationales that explain these relations. By deliberately analyzing the variation in adoption, disaggregated by wealth status, and by carrying out additional in-depth interviews, we have shown that differences in wealth status explained the preferred targeting by extensionists, thereby providing direct access to the improved seed, support in the construction of DLS and associated knowledge. Our results also show that poorer farmers with less resource are not

likely to eventually adopt, once they become familiar with the technology. Although such farmers might indeed get access to the technology and knowledge in one way or another, they may choose not to adopt improved seeds and associated practices because the technology does not fit their socio-economic conditions: they are too poor and their farms are too small.

These findings lead to questions about extension practices and technology development. The extension practices, as we found in this study, showed a common bias (conscious or unconscious) towards targeting the relatively wealthy farmers. This implies that the poorest farmers did not benefit from the material and financial support, and only had indirect access to the knowledge on improved practices. We found that in the current context, the technologies did not fit these poor farmers' reality. Improved varieties represent a high-input technology: more labor is needed for tillage and ridging, and investments in fertilizer, crop protection and storage may be needed to capitalize on the expensive seed and labor inputs. This is within the reach of wealthy farmers for at least part of their potato fields; for the farmers who do not have these resources, the improved technology is simply not an option, even if they had direct access to seed, information and training. This means that calls for a pluralistic extension model, which takes the poorest farmers into account (see Dersseh *et al.*, 2016), may only partially address the problem. The findings from this study show that there is merit to consider offering farmers a range of technology options (like different sizes and materials for construction of diffuse-light storage) and information on costs and benefits of technological options (like the trade-offs for less frequent tillage before and after planting). Associated micro-credit services may also prove crucial for poorer farmer to be able to invest in crop production. Moreover, there is a need to offer farmers a room to experiment and assess outcomes. As a result, different combinations of improved production practices may be adopted.

References

Abebe, G.K., J. Bijman, S. Pascucci, and O. Omta. (2013). Adoption of improved potato varieties in Ethiopia: the role of agricultural knowledge and innovation system and smallholder farmers' quality assessment. Agricultural Systems 122: 22-32.

Asfaw, S., B. Shiferaw, F. Simtowe, and G.M. Haile. (2011). Agricultural technology adoption, seed access constraints and commercialization in Ethiopia. Journal of Development and Agricultural Economics 3(9): 436-447.

Beckford C.L. (2002). Decision-making and innovation among small-scale yam farmers in Central Jamaica: A dynamic, pragmatic and adaptive process. The Geographical Journal 168(3): 248-259.

Berihun B, and G. Woldegiorgis. (2013). Potato Research and Development in Ethiopia: Achievements and Trends, ed. In: G. Woldegiorgis, S. Schulz, and B. Berihun. Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 35-44.

Byerlee D, D. Spielman, D. Alemu, and M. Gautam. (2007). Policies to promote cereal intensification in Ethiopia: A review of evidence and experience. IFPRI Discussion Paper. 00707, IFPRI, Washington, DC.

Creswell, J.W. (2009). Research design: Qualitative, quantitative, and mixed methods approaches (3rd ed). Sage publications, Thousand Oaks, USA.

CSA (Central Statistical Agency). (2011). Agricultural sample survey 2010 / 2011 (2003 E.C.), volume III, report on farm management practices (private peasant holdings, meher season). May, Addis Ababa.

Cunguara, B. and K. Moder. (2011). Is agricultural extension helping the poor? Evidence from rural Mozambique. Journal of African Economies 20(4): 562–595.

Dersseh, W.M., Y.T. Gebresilase, R.P.O. Schulte, and P.C. Struik. (2016). The analysis of potato farming systems in Chencha, Ethiopia: Input, output and constraints. American Journal of Potato Research 93:436–447.

Field, A. (2009). Discovering statistics using SPSS (3rd ed.). London: Sage.

Gildemacher, P.R., W. Kaguongo, O. Ortiz, A. Tesfaye, G. Woldegiorgis, Wagoire, R. Kakuhenzire, P.M. Kinyae, M. Nyongesa, P.C. Struik, and C. Leewis. (2009). Improving potato production in Kenya, Uganda and Ethiopia: A system diagnosis. Potato Research 52: 173–205.

Hirpa, A., M.P.M., Meuwissen, A. Tesfaye, W.J.M. Lommen, A.G.J.M. Oude Lansink, A. Tsegaye, and P.C. Struik. (2010). Analysis of seed potato systems in Ethiopia. American Journal of Potato Research 87: 537-552.

Hirpa, A., M.P.M. Meuwissen, I.A. van der Lans, W.J.M. Lommen, A.G.J.M. Oude Lansink, A. Tsegaye, and P.C. Struik. (2012). Farmers' opinion on seed potato management attributes in Ethiopia: A conjoint analysis. Agronomy Journal 104: 1413–1424.

Ilbery, B.W. (1977). Point score analysis: a methodological framework for analysing the decision-making process in agriculture. Journal of Economic and Social Geography 68: 66-71.

Khalil, I., E. Haque, and M.Z. Hoque. (2014). Adoption of recommended potato (Solanum tuberosum) production technologies by the potato growers of some selected areas of Bangladesh. Bangladesh Journal of Agriculture Research 39(1): 79-92.

Kolech, S.A., D. Halseth, W.D. Jong, K. Perry, D. Wolfe, F.M. Tiruneh, and S. Schulz. (2015). Potato variety diversity, determinants and implications for potato breeding strategy in Ethiopia. American Journal of Potato Research 92(5): 551–566.

Labarta, R. (2015). The effectiveness of potato and sweet potato improvement programmes from the perspectives of varietal output and adoption in Sub-Saharan Africa. In: T. Walker and J. Alwang (Eds.), Crop improvement, adoption and impact of improved varieties in food crops in sub-Saharan Africa. CGIAR and CABI, pp. 164-182.

Limenih, B., T. Tefera, and E. Lahiff. (2013). Determinants of adoption of improved potato varieties in Welmera Woreda. In: G. Woldegiorgis, S. Schulz, and B. Berihun, (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 279-298.

Mazengia, W., R. Schulte, Y. Tadese, D. Griffin, S. Schulz, and P.C. Struik. (2016). The farming systems of potential potato production areas of Chencha, Southern Ethiopia. In: J. Low, M. Nyongesa, S. Quinn, and M. Parker (Eds.), Potato and sweet potato in Africa: Transforming the value chains for food and nutrition security, pp. 382-396.

Moser, C.M, and C.B. Barrett. (2006). The complex dynamics of smallholders adoption: the case of SRI in Madagascar. Agricultural Economics 35: 373-388.

Mulatu, E, E.O. Ibrahim, and E. Bekele. (2005). Improving potato seed tuber quality and producers' livelihoods in Hararghe, Eastern Ethiopia. Journal of New Seeds 7(3): 31 – 56.

Phiri, D., S. Franzel, P. Mafongoya, I. Jere, R .Katanga, and S. Phiri. (2004). Who is using the new technology? The association of wealth status and gender with the planting of improved tree fallows in eastern province, Zambia. Agricultural Systems 79: 131–144.

Pircher, T., C.J.M. Almekinders, and B.C.G. Kamanga. (2012). Participatory trials and farmers' social realities: understanding the adoption of legume technologies in a Malawian farmer community. International Journal of Agricultural Sustainability 11(3): 252-263.

Rogers, E.M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.

Schulte-Geldermann, E. (2013). Tackling low potato yields in Eastern Africa: an overview of constraints and potential Strategies. In: G. Woldegiorgis, S. Schulz, and B. Berihun (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 72-80.

Tadesse, Y., C.J.M. Almekinders, R.P.O. Schulte, and P.C. Struik. (2016). Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. Experimental Agriculture. https://doi.org/10.1017/S001447971600051X

Tesfaye, A., K. Bedane, C. Yirga, and G. Woldegiorgis. (2008). Socioeconomics and technology transfer. In: G. Woldegiorgis, E. Gebre, and B. Lemaga (Eds.), Root and tuber crops: The untapped resources. Addis Abeba, Ethiopia: Ethiopian Institute of Agricultural Research, pp. 131–151.

Tesfaye, A., G Woldegiorgis, and W. Kaguongo. (2013). Adoption and impact of potato production technologies in Oromiya and Amhara regions. In: G. Woldegiorgis, S. Schulz, and B. Berihun (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 256-278.

Wale, E., and A.Yalew. (2007). Farmers' variety attribute preferences: Implications for breeding priority setting and agricultural extension policy in Ethiopia. Journal Ccompilation African Development Bank: 379-396.

Walker T. and J. Alwang, (2015). Crop improvement, adoption and impact of improved varieties in food crops in sub-Saharan Africa. CGIAR and CABI.

Woldegiorgis G, E. Gebre, and B. Lemaga. (2008a). Potato variety development. In: G. Woldegiorgis, E. Gebre, B. Lemaga (Eds.), Root and tuber crops: The untapped resources. Addis Abeba, Ethiopia, Ethiopian Institute of Agricultural Research, pp. 15–32.

Woldegiorgis, G., E. Gebre, and B. Lemaga. (2008b). Potato agronomy. In: G. Woldegiorgis, E. Gebre, and B. Lemaga (Eds.), Root and tuber crops: The untapped resources. Addis Abeba, Ethiopia, Ethiopian Institute of Agricultural Research, pp. 33-52.

Woldegiorgis, G., K. Negash, A. Solomon, A. Chindi, and B. Lemaga. (2013). Participatory potato seed production: experiences from West and Southwest Shewa, and Gurage Zones. In: G. Woldegiorgis, S. Schulz, and B. Berihun (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 152 -172.

CHAPTER 3

Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia

This chapter is based on the article: Tadesse, Y., C.J.M. Almekinders, R.P.O. Schulte, and P.C. Struik. (2016). Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. *Experimental Agriculture 53 (4): 481 - 496*

Abstract

Potato is a high-yielding crop that can contribute to food security for subsistence farmers in Sub-Saharan Africa. However, there are many prerequisites for potato production to meet its full potential. One of these is the introduction of improved varieties. Traditionally, such interventions are performed by government agencies or Non-Governmental Organisations (NGOs). To understand the diffusion of seed tubers ('seeds') of new potato varieties in farmer networks we analysed social factors influencing the sharing of improved seed potatoes among farmers in Chencha, Ethiopia. We collected primary data from 166 farmers through interviews and analysed 146 seed transactions using descriptive statistics. We used seed flow mapping to visualize seed sharing practices among farmers. We found that the social networks of farmers are differentiated by wealth, gender and religion, and that this differentiation affects the dispersion of new varieties through the farming communities: wealthier farmers shared seed tubers most frequently and poor farmers did not share seed at all. Seed sharing was influenced by, but not restricted to, gender and religion categories. Most sharing was with relatives (as gifts) and neighbours (in exchange for labour). Not all households in Chencha had equal access to seed disseminated through farmer seed networks because of 1) the targeting of the farmers by the NGO active in the region, 2) differences in frequency of sharing and 3) terms and motivation of the transactions related to the sharing of seed of improved varieties. Our results show that wealthy farmers most effectively multiply and share the seed of new varieties with medium-wealthy and poor farmers. This study shows that for the introduction of new technologies into a community the dynamics of social differentiation within the community need to be understood. Without such understanding it is difficult to know how a targeting strategy can work out.

Introduction

Potato production currently covers about 160,000 ha in Ethiopia, largely in smallholder systems where production is at subsistence level; the national average yield (9 t/ha) is far below attainable yields of 40 t/ha on research fields (APHRD, 2009; Berihun and Woldegiorgis, 2013; CSA, 2014). The major factors that hinder potato productivity are poor production and management practices, limited access to clean and affordable seed tubers, potato diseases (Gildemacher *et al*., 2009; Hirpa *et al.*, 2010; Bekele *et al*., 2013), declining soil fertility (Gebremedhin *et al.*, 2001) and weak linkages between research and extension services (Berihun and Woldegiorgis, 2013). These factors negatively affect the importance of potato as a staple food, and a source of income and nutrient-rich food among smallholders (Kolasa, 1993; Hirpa *et al*., 2012). The introduction and promotion of new varieties, use of quality seed and other production technologies are the main strategies of the Ethiopian Institute of Agricultural Research to improve potato production and the livelihood of low income farmers (Berihun and Woldegiorgis, 2013).

Currently, more than 98% of the planted potato seed tubers ('seed') are saved by farmers (Gildemacher *et al*., 2009). This means that (semi-) public and private sector institutions only supply seed to relatively few farmers. This situation is typical for the seed systems in many countries and most staple crops in Africa (Rubyogo *et al*., 2010; Louwaars and De Boef, 2013, McGuire and Sperling, 2016). A small formal seed sector does however not imply that farmers are deprived of improved varieties. If the introduction of improved varieties by formal or semi-formal entities is tied into a dynamic informal system of farmer-to-farmer seed exchange, the diffusion of the new varieties may actually be very effective. It has been claimed that informal seed exchange mechanisms may actually provide farmers with better access to improved seed than the formal seed sector introductions, for a range of reasons: the sources of seed are usually nearby and timely available, farmers can verify the quality and performance of the material, and the exchange may not require cash (e.g. Almekinders *et al*., 1994; Seboka and Deressa, 1999; Sperling and McGuire, 2010; Coomes *et al*., 2015). It has however also been observed that these informal farmer-based exchange mechanisms encounter social barriers that are present in rural society in many different forms (see Coomes *et al.*, 2015). For example, barley seed flow depends on the performance of farmers bridging intergroup connection (Abay *et al.*, 2011). In the context of sorghum and maize, seed exchange is limited to neighbourhood groups (Labeyrie *et al.*, 2014). Seed dissemination is also associated with the availability of hired

labour (Jones *et al.*, 2001) and reciprocal ties involving labour exchange and sharing-cropping arrangements that determine the nature of access to seed (McGuire, 2008). In addition, social ties involved in seed exchange can be vulnerable to the change in the structure of local institutions (Samberg *et al.*, 2013). Few studies have however empirically addressed the flow of seed from farmer-to-farmer to assess the effect of these social barriers on the diffusion of seed of newly introduced varieties (Grisley and Shamambo, 1993; Cromwell and Tripp, 1994; McGuire, 2007). These studies pointed out that seed exchange often remains restricted within certain social groups shaped by gender, kinship or ethnicity. We studied practices of potato seed sharing of recently introduced improved potato varieties in the Chencha *wereda* of the Southern Nations, Nationalities, and Peoples' Region in Ethiopia. Our study specifically analysed how social differences defined by wealth, gender and religion, influenced the farmer-to-farmer diffusion. Next to the frequency of sharing, we also assessed the terms and motivations for sharing seed and the amount of seed that was shared. We discuss the results in relation to the potential of farmer networks to provide access to improved planting materials.

Methods

Study setting, project context and respondent selection

Field data were collected from June to October, 2013 in four *kebeles* of the Chencha *wereda*. The Chencha *wereda* is located in the Gamo Gofa zone, 40 km from Arba Minch in the southern part of Ethiopia. Potato was introduced into this *wereda* about five decades ago, and is more planted in the 33 out of the 45 *kebeles*, where climate is cooler (2578-3200 m above sea level), soils are relatively fertile, and land holdings somewhat larger. In these *kebeles,* each household grows new and/or old potato varieties, although the area and production technology vary strongly, depending on household resources (Tadesse *et al.*, 2017).

We carried out the research in four of these 33 *kebeles*: Losha, Laka, Yoyera and Gendo Gembella; the total number of households of these *kebeles* is 407, 306, 370 and 273, respectively. Heads of households in each *kebele* are dominantly male (87-97%). The households in Laka (93%) and Gendo Gembella (95%) are primarily Orthodox. In the case of Losha (80%) and Yoyera (75%) Protestant followers are proportionally abundant. In 2010 and 2011, Vita, an Irish based Non-Governmental Organization (NGO) that is active in the region since 2006, provided 500 kg of seed tubers of the variety Gudene or Jalene to 120 potato farmers (30 farmers per *kebele).* These farmers were also trained in the use of improved potato

production and management practices, such as fertilization and ridging. The NGO had selected the 120 farmers on the basis of their capacity to acquire inputs, for being known to the project staff as 'hard-working'. The NGO expected that these farmers would be functioning as models for their neighbouring farmers and that in this way improved technology would spread to the rest of the community.

From the list of 30 farmers in each of the four *kebeles* who originally accessed improved seed potatoes, we randomly selected 5 in each *kebele*. We used these farmers as the entry points for the seed network, hereafter referred to as "first generation farmers". To identify additional participants who acquired seed from the first generation farmers, we used the snowball sampling technique (Creswell, 2007) to trace how the variety spread from these farmers through the communities and beyond: first generation farmers were asked to whom they had provided seed tubers of the improved varieties after the first harvest, in order to identify farmers that we refer to in this study as second and subsequent third generation farmers. A total of 178 recipients were identified, of which twelve could not be located for an interview. The data collection, thus, involved 20 first generation, 125 second generation and 21 third generation farmers. Together, during planting time, potato seed was shared between them on 146 occasions, namely 125 between first and second generation farmers and 21 between second and third generation farmers. Farmers within the seed sharing networks were not representative for the wider population. This is because the project selected recipient farmers on purpose, and we 'traced' the seed from there onwards, with the aim of understanding the pattern of seed sharing and dissemination. In this study, we use 'sharing' or 'transaction' for each seed lot that a farmer provides to another farmer. We consider the sharing had different conditions. We called these conditions the 'terms of sharing', i.e. as a gift, in exchange for labour or otherwise, or on the basis of cash.

Data collection and analysis

The first author conducted 45-60 minute in-depth interviews. Farmers were asked about three domains of information: 1) their demographic characteristics (gender, age, wealth status, and religion), 2) the source of seed acquisition and associated relations, 3) their seed sharing and seed saving practices. During interviews, farmers within the seed sharing networks identified the type of social relationship (relatives, neighbours, friends or acquaintances) they had with seed providers and/or receivers. The interviews involved those found home, either man or wife.

There were also cases where both man and wife, or mother and the oldest child were part of the interview; this was the case when they had active role in the seed sharing.

To define the economic status of each respondent, the local administrators and six to eight community members were invited to an open discussion. This was done in each *kebele.* Participants were asked to describe the characteristics of households of different wealth status. They used size of land holding, number of livestock, house structure (floor area and construction materials) and number and age of '*enset*' (*Ensete ventricosum*) plantations as the main indicators and utilized them for categorizing each of the participants as relatively wealthy, medium-wealthy and poor (Table 3.1).

The data analysis consisted sequentially of transcription, identifying themes, mapping and interpretation. SPSS® was used for descriptive statistics - a chi-square test of independence. To visualize seed sharing networks we used the Node® Excel® software.

Table 3.1. Characteristics of wealth status at household level.

Wealth indicators	Wealthy	Medium-wealthy	Poor
Land holding (ha)	>1.0	0.5-1.0	<0.5
Number of livestock	3-4 ox, 4-7 cow, 5-7 sheep	1-2 ox, 1-3 cow, 2-4 sheep	1 cow, 0-2 sheep
Number of houses	≥5	3-4	1-2
House structure			
Construction material	Corrugated iron sheet and wood	Corrugated iron sheet and wood	Bamboo and barley leaf
Floor area-radius (#feet)	10-12	7-10	5-7
Number and age of '*enset*' stems	>300 stems; some flowering plants	150-300 stems, few flowering plants	<100, No flowering plants

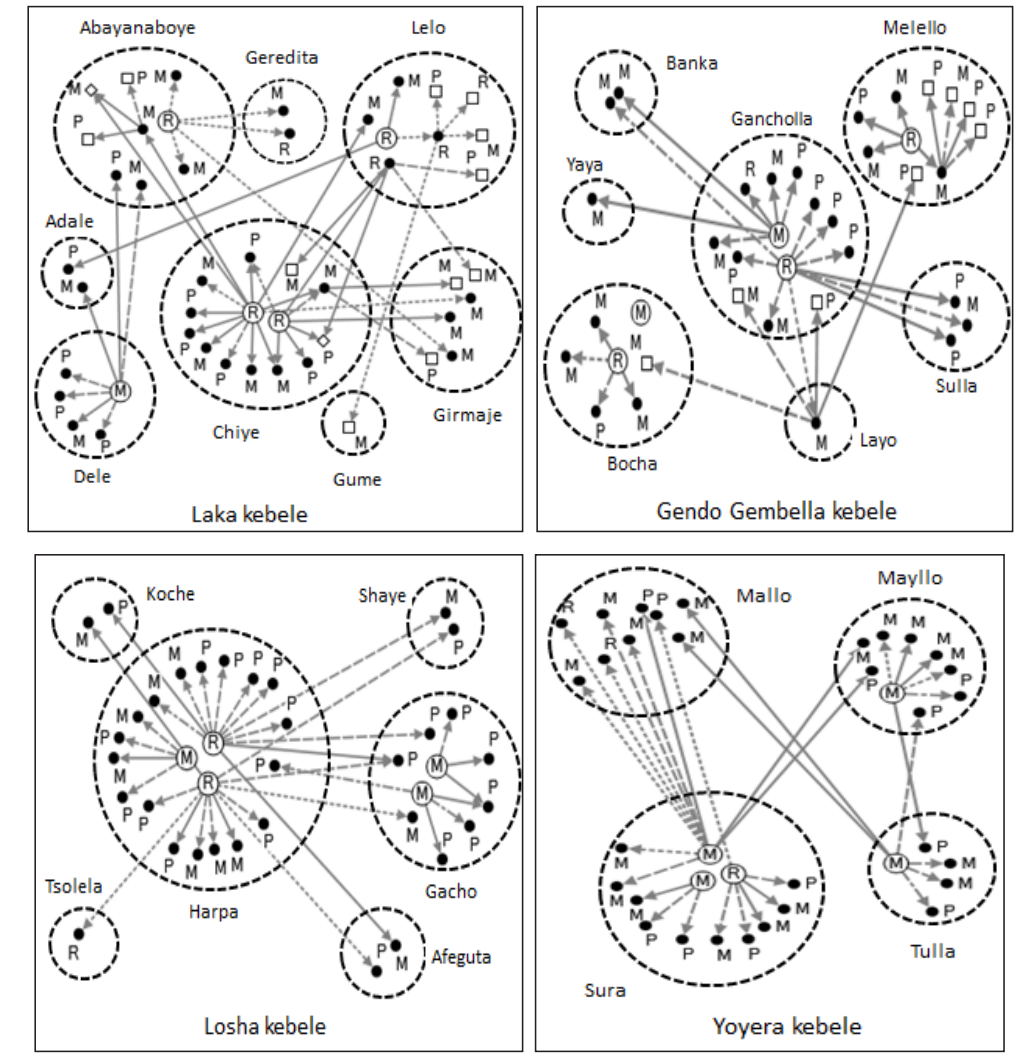
one feet ≈ 30 cm

Results

Figure 3.1 maps the farmer to farmer seed flows in the four *kebeles,* with the information on wealth class and type of relationship between seed sharers. This information in combination with information on gender, the terms of sharing and the amount of seed shared forms the basis for data and analysis in the presented tables.

Farmers' socio-economic characteristics

The proportion of wealthy farmers was highest in the group of first generation farmers, i.e. the farmers who directly received seed from the project intervention, whereas there were no poor



*Acquaintance is a farmer who has no close association with seed owner and seed owner knows little about him/her

Fig 3.1. Distribution patterns of seed potato among farmers of different wealth status over three generations, between and within villages in four *kebeles*.

farmers within this group (Table 3.2). In the second and third generation farmers approximately 50% of the farmers were poor. The fraction of male and female farmers was similar over the three generation of farmers. The first generation farmers had the largest fraction of young farmers (18-40 years old). Orthodox and Protestant farmers were more or less represented equally in the first generation of farmers, but in the second and third generation farmers there were more Orthodox farmers.

Table 3.2. Socio-economic characteristics of first, second and third generation farmers

Attributes	First generation farmers n=20		Second generation farmers n=125		Third generation farmers n=21		Pearson χ^2
	n	(%)	n	%	n	%	
Wealth class							
Wealth	11	(55)	7	(6)	1	(5)	40.270*** (p=0.000)
Medium	9	(45)	63	(50)	9	(43)	
Poor	0	(0)	55	(44)	11	(52)	
Gender							
Male	16	(80)	77	(62)	11	(52)	3.578 (p=0.167)
Female	4	(20)	48	(38)	10	(48)	
Age (year)							
18-40	12	(60)	42	(34)	4	(19)	9.195* (p=0.072)
41-60	5	(25)	53	(42)	13	(62)	
61-80	3	(15)	30	(24)	4	(19)	
Religion							
Orthodox	9	(45)	79	(63)	19	(90)	9.597*** (p=0.008)
Protestant	11	(55)	46	(37)	2	(10)	

*Significant association between the type of generation and farmers' age ($p<0.01$); ***at $p<0.01$, the type of generation and farmers' wealth status are dependent on one another; and type of generation and religion; (n=146)

Farmer to farmer seed sharing between wealth classes

All but one of the first generation farmers shared potato tuber seed, with 3 to 13 other farmers; on average they shared seed 6.6 times with others. The one farmer who did not share was a medium-wealthy farmer in Gendo Gembella who lost his initial seed lot because of bacterial wilt. The sharing of seed by the first generation farmers resulted in a total of 125 second generation farmers. From the 125 second generation farmers, only 6 shared seed with 2 to 4 other farmers; on average they shared 3.5 times. None of the second generation farmers from Losha and Yoyera *kebele* shared seed with other farmers. This was mainly because they had planted only for one season, and/or they wanted first to multiply potatoes for their own use.

Wealthy farmers shared seed with other wealthy farmers in only 7% of the total number of transactions (n=94). Instead, wealthy farmers most often shared seed with medium-wealthy

(52%) and poor farmers (40%). The seed sharings of medium-wealthy farmers (n=52) showed a similar pattern: 44% was with medium-wealthy and 54% was with poor farmers. None of the poor farmers shared seed with other farmers. Of all seed shared (n=146), 43% was between relatives - parents, children, sisters, brothers and in-laws - and 33% was between neighbours. The rest was between acquaintances (16.5%) and friends (7.5%).

The effect of gender and religion on seed sharing

On average, male farmers shared seed with 6 other farmers, while female farmers shared with 5 other farmers. Male farmers shared seed more often with male farmers than with female farmers (68 and 32 times out of 100, respectively) whereas female farmers shared seed more or less equally with female and male farmers (26 and 20 out of 46, respectively) (Table 3.3). Male farmers mainly shared seed with their male neighbours. Female farmers shared seed mostly with their female relatives, and to a lesser extent with male farmers they acquainted. They hardly shared with female acquaintances. No male farmers shared seed with female friends, or vice versa.

The majority of Orthodox farmers shared seed with Orthodox farmers only (Table 3.3). Protestant farmers also disseminated seed more often to farmers of their own religion. On the few occasions that Orthodox farmers shared with Protestant farmers, in most cases this involved their relatives and neighbours. In the case of Protestant farmers, sharing of seed with farmers was mainly with neighbours followed by relatives.

Seed sharing within and between villages

Wealthy and medium-wealthy farmers shared seed more often with farmers within the same village (56% and 69%, respectively), mostly with their neighbours (approximately 40%) (see Fig. 3.1). Sharing of seed outside the village was predominately with farmers they acquaint by wealthy farmers and with relatives by medium-wealthy farmers.

Male farmers shared seed more within (average of four farmers) than outside (average of two farmers) their villages (Table 3.4). In most cases they shared with their neighbours followed by relatives. Female farmers, however, shared more or less equally with others outside their villages; on average with three farmers, mainly relatives.

Table 3.3: Seed sharing of first and second generation farmers differentiated by social relation, and in and between gender and religion groups

Seed provider	Seed receiver												
	Male (n=88)						Female (n=58)						
	Relatives	Friends	Neighbours	Acquaintance	Total	Average no. of receivers	Relatives	Friends	Neighbours	Acquaintance	Total	Average no. of receivers	Pearson χ^2
Gender													
Male (n=16)	19	8	30	11	68	4	20	0	11	1	32	2	7.912***
Female (n=9)	7	0	3	10	20	2	17	3	4	2	26	3	(p=0.005)
	Orthodox (n=98)						Protestant (n=48)						
Religion													
Orthodox (n=13)	35	3	17	12	67	5	2	0	2	1	5	<1	43.289***
Protestant (n=12)	12	1	15	3	31	3	14	7	14	8	43	4	(p=0.000)

***Significant association between the seed provider and the seed receiver gender; between the seed provider and the seed receiver religion; at p<0.01

Table 3.4: The sharing of seed of farmers with other farmers within and between villages by gender

Seed provider	Seed receiver												
	Within village (n=89)						Outside village (n=57)						
	Relatives	Friends	Neighbours	Acquaintance	Total	Average no. of receivers	Relatives	Friends	Neighbours	Acquaintance	Total	Average no. of receivers	Pearson χ^2
Gender													
Male (n=16)	23	7	30	5	65	4	15	2	9	8	34	2	2.852*
Female (n=9)	12	1	6	5	24	3	13	1	3	6	23	3	(p=0.091)

*The relation between seed providers' gender and geographical seed dispersion was significant; at p<0.1; (n=146)

Terms and amount of seed sharing

Farmers shared seed with their relatives (43 %), neighbours (32%), friends (7%) and persons they acquainted (16%). The transactions were on different terms: as a gift, in exchange against labour, seed or straw, or on a cash basis. The terms and amount of seed tubers transacted depended on the amount of seed they had and their type of relationship (Table 3.4). It was also influenced for example by how well they knew the farmer and the level of mutual support in agricultural and social activities. A woman farmer, for instance, stated that "as compared to others I provided a large amount of seed to my neighbour as a gift because she helped me in transporting manure to different plots. She is also the one who looks after my children when I go to market." In this study, gift is used for seed that is given without explicit arrangement for payment or exchange.

Of all seed transactions (n=146), 34% was shared as a gift, mostly with relatives, whereas exchange was the basis for sharing in 38% of the cases, mostly between neighbours and relatives (Table 3.5). Acquaintances accessed seed almost exclusively on the basis of cash, but also 43% of the seed transactions between relatives, friends and neighbours was on the basis of cash. On average, seed transactions as gifts were amounting 22 kg of seed tubers, the exchanges among relatives, friends and neighbours were 31 kg. Overall, the largest amounts of potato seed were shared on terms of cash.

Gift, exchange and cash were more or less equally important terms of sharing among wealthy and medium-wealthy farmers (Table 3.6). They shared seed with poor farmers mostly on the basis of exchange (53%) or as a gift (33%). Cash was less important as a term for sharing with the poor farmer.

Exchange (48%) was the dominant term of seed transaction among male farmers while many female farmers shared seed most often as a gift (43%), manly with other female farmers (57%) (Table 3.5). Cash transactions were similarly important for male (26%) and female farmers (32%).

Motivations of farmer to share seed of new potato varieties

The introduction of a new variety was the dominant reason for farmers to share potato seed as a gift with relatives and to sell to acquaintances (Table 3.7). One of the medium-wealthy farmers, for instance, reported: "I shared seed with my parents and brothers because I have got

Table 3.5: Terms and amounts of seed dispersed through various social relations of suppliers with receivers.

Terms of seed transaction	Social relation												Pearson χ^2
	Relatives (n=63)			Friends (n=11)			Neighbours (n=48)			Acquaintances (n=24)			
	n	kg	#Av	n	kg	Av	n	kg	Av	n	kg	Av	
Gift	33	778	24	3	40	13	13	245	19	0	0	0	68.901*** (p=0.000)
Exchange	22	875	40	6	150	25	26	655	25	1	100	100	
Cash	8	418	52	2	250	125	9	356	40	23	2738	119	

#Average kilogram of seed shared with a farmer; *** At $p < 0.01$, the terms of seed transaction and the type of social relations of suppliers with receivers are dependent on one another; (n=146)

a new variety that has a high yield as compared to what we normally used to plant." This also explains why farmers shared most seed after the first harvest. When discussing if they shared seed in following seasons, farmers said they saw no use in it, because they had shared the seed of the new variety with those who they considered should have the variety as well. Labour support in agricultural activities (transporting farm yard manure, land preparation, planting and harvesting) was another reason for sharing seed, mainly with relatives and neighbourhoods. Farmers stated that those who supported them in agricultural activities usually had limited financial capacity and were not able to buy the seed of new varieties. This was mentioned more often among wealthy farmers. One wealthy farmer explained his reason for sharing as follows: "If I could not get the support from my three relatives and four neighbours, it would have been very hard to plant all my potato seed and transport the harvest. Planting more potato demands more labour, this is expensive for me. Sharing seed tubers with my supporters was the best option for paying for the labour of my relatives and neighbours." An important reason to share seed with neighbours as a gift was to maintain their relationship. In this case the initiative for sharing potato seed was mostly from farmers who produced the seed. They said that these farmers might not be very willing to provide labour support in the next cropping season if they were not given some seed. In four cases (out of the total of 146 transactions) farmers shared the seed as a gift 'out of precaution.' One farmer said: "This year I planted the new potato near to a farmer's house but far from my own. To prevent stealing, I shared seed with him as a gift."

The feeling of social responsibility was another reason for sharing seed, particularly with relatives and farmers in the neighbourhood who were senior and poor. This happened mostly when the farmers recognized the presence of a new variety and seed owners felt those farmers

Table 3.6: Terms of seed sharing between farmers of different wealth classes and gender

Seed provider	Seed receiver												Pearson χ^2
	Wealthy (n=8)				Medium (n=72)				Poor (n=66)				
	Gift	Exchange	Cash	Total	Gift	Exchange	Cash	Total	Gift	Exchange	Cash	Total	
Wealth status													
Wealthy (n=12)	1	0	6	7	17	13	19	49	14	21	3	38	
Medium (n=13)	0	0	1	1	7	8	8	23	8	14	6	28	12.821
Poor (n=0)	0	0	0	0	0	0	0	0	0	0	0	0	(p=0.234)
	Male (n=88)				Female (n=58)								
Gender													
Male (n=16)	19	31	18	68	7	17	8	32					16.301**
Female (n=9)	5	5	10	20	15	6	5	26					(p=0.012)

**Significant at p<0.05

Table 3.7: Motivations of farmers for sharing seed potatoes

Seed providers' motivation	Number of seed receivers (n=146)												Over all motivation (n=146)
	Relatives (n=63)			Friends (n=11)			Neighbours (n=48)			Acquaintance (n=24)			
	Gift	Exchange	Sell	Gift	Exchange	Sell	Gift	Exchange	Sell	Gift	Exchange	Sell	
New variety	20	0	4	2	1	2	2	5	8	0	1	23	68
Labour support	-	17	1	0	5	0	-	20	0	0	0	0	43
Maintain relationship	10	6	2	1	0	0	6	2	1	0	0	0	28
Social responsibility	2	1	0	0	0	0	3	1	0	0	0	0	7
Total	32	24	7	3	6	2	11	28	9	0	1	23	146

would be keen to have the new cultivar and harvest similar yields. Respondents also said that providing seed for free to poor and elder farmers improves one's social acceptability.

On-farm seed saving

The practice of saving seed of the new variety from the harvest for next planting differed significantly for farmers of different wealth categories (χ^2=12.235, p=0.002, at 99% confidence interval). All wealthy (n=8), 82% of medium-wealthy farmers (n=72) and 59% of the poor farmers (n=66) who received seed from other farmers, maintained the seed of the newly introduced variety. Farmers listed four major reasons for not saving the seed of the new varieties which they had acquired through their social network: 1) potato disease, 2) small volume of seed, 3) lack of agronomic knowledge and 4) supplying potato to the local market as a ware. The most important reason for not saving seed varied between wealth classes. For 6 of the 13 medium-wealthy farmers who did not save the seed it was to meet the need for cash: they sold all potatoes shortly after harvest (n=13). For medium-wealthy farmers (5 of 13) who acquired a relatively larger volume of seed from other farmer (25-100 kg) it was the loss of a major portion of potato crop because of disease. They associated the disease (mostly wilting) with the poor quality of seed they had accessed. For most poor farmers (24 of 39), the small quantity (5-10 kg) of seed they had acquired was the main reason for saving no seed: this only allowed for planting a small area and all harvested tubers were used for consumption. Lack of knowledge on the improved potato production practices were also another reason (9 of 39). This resulted in minimal yield that could serve only for consumption. Farmers described the reasons for harvesting low yields as follows: "the way I cultivated the new and old potato varieties was the same", "I was not used to variety attributes and management", and "I applied least cultivation frequency and small amount of fertilizer." Supplying potato to local markets was only a reason for 3% of poor farmers who did not save seed.

Discussion

In this paper, we analysed how social differences influence the dissemination of seed of recently introduced new potato varieties among farmers in rural communities in Ethiopia. Our data showed that the flow of potato seed of new varieties in the informal seed system was influenced by wealth, gender and religion, but also that the diffusion of seed was not exclusively restricted within wealth, gender and religion categories.

The farmers' wealth status was the most important factor influencing the sharing of seed. As compared to medium-wealthy farmers, wealthier farmers shared seed with a larger number of poor and medium-wealthy farmers. Since poor farmers in this study did not share seed - because the amount of seed they accessed and planted was too small and they often lost their crop due to potato diseases and lack of agronomic knowledge - the seed of the new varieties flowed one-directionally, down from higher wealth categories to the lowest.

We also found that both male and female farmers shared seed of improved potato varieties, although men shared more with men, and women more with women. As compared to men, the female farmers shared seed potatoes more often with a farmer of the other gender. This is perhaps because, as compared to male famers, women farmers in this study also seek labour support for agricultural activities, but they have less cash to contract labour. Women also had a dominant role in sharing seed outside their villages, mostly in small quantities as a gift to relatives. This can be explained by the fact that when women in Chencha marry, they move to the home in the village of the husband; this gives women more close relatives outside the village with whom they share seed. Seed sharing with acquaintances, mainly for cash, facilitated sharing across gender. These acquaintance networks are highly valued by farmers who are financially able to buy relatively large volumes of seed. Cross-societal sharing between wealth categories, genders and religions was mostly through family ties and in the form of gifts. Seed-for-labour was an important mechanism for poor farmers to access seed of improved varieties. This aligns with the notion that labour-neighbour networks are an important means for accessing resources and benefits that cannot be gotten through kinship networks (Hoang *et al*., 2006) or because of lack of cash. This further indicates that such social networks also represent a form of insurance that provides seed and food security (Fafchamps and Lund, 2003).

Studies in other crops also show that wealthy farmers play a more significant role in the diffusion of new varieties (e.g. Subedi *et al*., 2003) and that poorer farmers are unlikely to be main diffusers because they do not have sufficiently large yields to cover their own demand (Sperling and Loevinsohn, 1993). In this study, however, we unpacked the influence of social differentiations in the diffusion of seed potato by tracing the seed and analysing the seed sharing characteristics. The collected data demonstrate that, overall, 2 years after the introduction of seed lots by the NGO, 7 times more farmers had accessed the seed of the new varieties that the NGO introduced to a limited number of farmers. No poor farmers received seed tubers directly from the NGO. The fraction of poor farmers, however, had increased to 40% in the group of

farmers who had accessed seed 2 years later, although only almost half of them saved seed for the next planting season. The conclusion that the wealthier farmers are the most frequent seed sharers, and the most effective in diffusing improved seed through informal seed diffusion, also to the poor, should however be treated with caution. In this study the first generation farmers received 500 kg of seed tubers which allowed them to plant a considerable area with the new varieties: the harvest was likely to be large enough to share 5-10 kg with two to six others. In addition, they had support from the technicians of the NGO. Farmers who received 5-10 kg amounts of seed tubers from the first or second generation farmers must have needed time to evaluate and bulk-up the seed before sharing it with others. Similarly, however, the assumption that poorer farmers would be frequent sharers of seed if they had been provided with adequate amounts (plus inputs and technical support) is also questionable: most research so far indicates that the poorest farmers are in the most difficult position to save seed from their own harvest.

Conclusions

The results from this study show that the farmer seed network was a powerful mechanism for the diffusion of seed of the new potato varieties: seed sharing provided access to the varieties by many more farmers than only the group who initially received tuber seed from the NGO. The seed which was introduced by the NGO crossed social barriers formed by differences in wealth, gender and religion, but the study also confirmed that there is no equal access to seed in informal seed networks, as suggested by Coomes *et al*. (2015). For farmers with limited financial capacity, the relationships with better-off neighbours provided them access to seed of improved varieties, in exchange of their labour. The flow of planting material of the new varieties from wealthy to medium and poorer classes suggests a strong interdependence among different wealth groups which may strengthen social safety nets and informal 'insurance' institutions. It also means that poor farmers without such labour-opportunities may have had very limited access to the improved seed. Data also indicate that poor farmers are not very functional seed distributors in informal networks: they had difficulties to maintain the improved varieties after acquiring an initial seed lot because the initial volumes of seed they acquired were smaller, they lacked inputs and up-to-date agronomic knowledge, they had less land and thus less surplus to save, and may therefore have more difficulties to save seed for next planting or for sharing. From the point of view of the NGO, therefore, introduction of seed lots to wealthy and medium-wealthy farmers may well have been the most effective strategy. In other words, this study shows that introduction of new technologies into a community needs to understand the dynamics of social differentiation within the community. Without such

understanding it is difficult to know what targeting strategy can work and which will work best. In this study, introduction of seed of a new potato variety to better off farmers made it also available to the poorest. We do however not know how many of the poor did not access the new seed because they were not part of the social networks in which this new seed circulated. In terms of improving potato productivity among the poorest of the poor, other, integrated intervention strategies have to be considered. The introduction of seed of improved varieties to poor farmers would need to be accompanied with access to the knowledge and inputs to successfully grow these varieties (Tadesse *et al*., 2017) and possibly the creation of opportunities for non-farm income generating activities and/or making low-interest loans available.

References

Abay, F., De Boef, W.S., and Bjørnstad, Å. (2011). Network analysis of barley seed flows in Tigray, Ethiopia: supporting the design of strategies that contribute to on-farm management of plant genetic resources. Plant Genetic Resources 9: 495–505.

Aistara, G. (2011). Seeds of kin, kin of seeds: the commodification of organic seeds and social relations in Costa Rica and Latvia. Ethnography 12: 490–517.

Almekinders, C.J.M., Louwaars, N.P. and de Bruijn G.H. (1994). Local seed systems and their importance for an improved seed supply in developing countries. Euphytica 78: 207-216.

APHRD (Animal and Plant Health Regulatory Directorate). (2009). Crop variety register, Issue No. 12, June, 2009, Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

Bekele, B., Abate, E., and Asefa, A. (2013). Viruses and bacterial wilt disease of potato in western Amhara. In G. Woldegiorgis, S. Schulz, B. Berihun (Eds.). Seed potato tuber production and dissemination: experiences, challenges and prospects, proceedings of the national workshop on seed potato tuber production and dissemination, 12-14 March 2012, Bahir Dar, Ethiopia: 241-255.

Berihun, B. and Woldegiorgis, G. (2013). Potato Research and Development in Ethiopia: Achievements and trends. In G. Woldegiorgis, S. Schulz, B. Berihun (Eds.). Seed potato tuber production and dissemination: experiences, challenges and prospects, proceedings of the national workshop on seed potato tuber production and dissemination, 12-14 March 2012, Bahir Dar, Ethiopia: 35-44.

Coomes, O.T., McGuire, S. J., Garine, E., Caillon, S., McKey, D., Demeulenaere, E., Jarvis, D., Aistara, G., Barnaud, A., Clouvel, P., Emperaire, L., Louafim, S., Martin, P., Massol, F., Pautasso, M., Violon, C., Wencélius, J. (2015). Farmer seed networks make a limited contribution to agriculture? Four common misconceptions. Food Policy 56: 41–50.

Creswell, J.W. (2007). Qualitative inquiry and research design: Choosing among five approaches (2nd ed.). Thousand Oaks, CA: Sage.

Cromwell, E., and Tripp, R. (1994). Proximity is a plus: the economics of farmer seed production and distribution in developing countries. Proceedings of the ILCA/ICARDA workshop on Seed Production by Smallholder Farmers. Addis Abeba. 13-15 June 1994. Addis Abeba: ILCA: 15-23.

CSA (Central Statistical Agency). (2014). Agricultural sample survey report on area and production (Private peasant holdings in Meher season). Addis Ababa: Statistical Bulletin.

Fafchamps, M., and Lund, S. (2003): Risk-Sharing Networks in Rural Philippines. Journal of Development Economics 71(2): 261–287.

Gildemacher, P., Kaguongo, W. Ortiz, A O., Tesfaye, Gebremedhin, W. Wagoire, W., Kakuhenzire, R. Kinyae, P., Nyongesa, M., Struik, P.C., and Leewis, C. (2009). Improving potato production in Kenya, Uganda and Ethiopia. Potato Research 52: 173–205.

Grisley W., and Shamambo, M. (1993): An analysis of adoption and diffusion of Carioca beans in Zambia resulting from an experimental distribution of seed. Experimental Agriculture 29: 379–386.

Hirpa A., Meuwissen, M.P.M., Tesfaye, A., Lommen, W.J.M., Oude Lansink, A.G.J.M., Tsegaye A., and Struik, P.C. (2010). Analysis of seed potato systems in Ethiopia. American Journal of Potato Research 87: 537-552.

Hirpa, A., Meuwissen, M.P.M., van der Lans, I.A., Lommen, W.J.M., Oude Lansink A.G.J.M., Tsegaye, A., and Struik, P.C. (2012). Farmers' opinion on seed potato management attributes in Ethiopia: A conjoint analysis. Agronomy Journal 104: 1413–1424.

Hoang, L.A., Castella, J.C. and P. Novosad. (2006). Social networks and information access: Implications for agricultural extension in a rice farming community in Northern Vietnam. Agriculture and Human Values 23: 513–527.

Jones, R.B., Audi, P.A., and Trippa, R. (2001) The role of informal seed systems in disseminating modern varieties: example of pigeon pea in semi-arid area of Kenya. Experimental Agriculture 37(4): 539-548.

Kolasa, K.M. (1993). The potato and human nutrition. American Potato Journal 70: 375–384.

Labeyrie, V., Rono, B., and Leclerc, C. (2014). How social organization shapes crop diversity: an ecological anthropology approach among Tharaka farmers of Mount Kenya. Agricultural and Human Values 31: 97–107.

Louwaars, N. P., de Boef, W. S., and Edeme, J. (2013). Integrated seed sector development in Africa: A basis for seed policy and law. Journal of Crop Improvement 27(2): 186-214.

McGuire, S.J. (2007). Vulnerability in farmer seed systems: farmer practices for coping with seed insecurity for sorghum in Eastern Ethiopia. Economic Botany 61(3): 211–222.

McGuire, S.J. (2008). Securing access to seed: social relations and sorghum seed exchange in eastern Ethiopia. Human Ecology 36: 217–229.

McGuire, S.J., and Sperling, L. (2016). Seed systems smallholder farmers use. Food Security 8: 179-195.

Rubyogo, J., Sperling, L., Muthoni, R., and Buruchara, R. (2010). Bean seed delivery for small farmers in sub-Saharan Africa: the power of partnerships. Society and Natural Resources 23: 285–302.

Samberg, L.H., Shennan,C., and Zavalet, E. (2013). Farmer seed exchange and crop diversity in a changing agricultural landscape in the southern highlands of Ethiopia. Human Ecology 41: 477–485.

Seboka B. and Deressa, A. (1999). Validating farmers' indigenous social networks for local seed supply in Central Rift Valley of Ethiopia. Journal of Agricultural Education and Extension 6: 245-254.

Sperling, L. and Loevinsohn, M.E.(1993). The dynamics of adoption: distribution and mortality of bean varieties among small farmers in Rwanda. Agricultural Systems 41: 441-453.

Sperling, L. and McGuire, S. (2010). Understanding and strengthening informal seed markets. Experimental Agriculture (46): 119-136.

Subedi, A., Chaudhary, P., Baniya, B.K., Rana, R.B., Tiwari, R.K., Rijal, D.K. and Jarvis, D.I. (2003). Who maintains crop genetic diversity and how?: implications for on-farm conservation and utilization. Journal of Culture and Agriculture 25(2): 41–50.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2017). Understanding farmers' potato production practices and use of improved varieties in Chencha, Ethiopia: implications for technology interventions. Journal of Crop Improvement. 10.1080/15427528.2017.1345817

Woldegiorgis, G., Gebre, E., Bedane, K., and Kassa, B. (2001). Country Profile on Potato Production and Utilization in Ethiopia. National Potato Research Programme Report. Ethiopian Agricultural Research Organization, Holetta Agricultural Research Center, Addis Ababa.

CHAPTER 4

Collective production and marketing of quality potato seed: Experiences from two cooperatives in Chencha, Ethiopia

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Abstract

In recent years, there has been a growing emphasis on farmer groups as a mechanism for improving seed quality and seed system efficiency. This paper aims to contribute to better understanding of the process and practice of seed potato cooperatives' formation and operation in Chencha, Ethiopia. Case studies of two seed cooperatives focused on why and how farmer groups organize, produce and market quality seed potato. We found that the support to the establishing of the two seed potato cooperatives focused more on improving the members' seed potato production capacity and less on building good governance in the seed chain. The complexity of maintaining seed quality as part of a collective effort was entirely overlooked and made the task of the quality assurance and control committee difficult without proper capacity and regulation. Maintaining seed quality implied rejection of seed and affected social relations. The challenges became magnified by the unforeseen incidence of bacterial wilt (*Ralstonia solanacearum).* The experiences show the challenges of decentralised production of quality seed by cooperative groups in a context where enforcement of rules and laws is difficult to achieve.

Introduction

Despite the limited success of cooperatives in the past (Desta, 1995; Brass, 2008; Francesconi, 2008; Shiferaw *et al.*, 2011), there is renewed interest in organising farmers into producer organisations (World Bank, 2007; Bernard *et al.*, 2010; Getnet and Anullo, 2012). Efforts to support smallholder farmers to climb out of subsistence farming through pooling their resources and efforts, and organising them into community groups or local agricultural cooperatives aim to facilitate farmers' market participation (ATA, 2012; Shiferaw *et al.*, 2011). Organising farmers in producer groups offers these farmers opportunities to reap benefits of economies of scale: it can reduce transaction costs (with improved access to information and new technologies) and improve the negotiation position with other value chain actors, leading to increased productivity (Shiferaw *et al.*, 2011; Bernard *et al.*, 2010). Reports often point to trust, good governance (equality of distribution of costs and benefit) and profitability as factors determining success or failure.

Farmer organisation is also fostered in the area of seed production, especially in countries like Ethiopia where seed sector development is currently high on the agenda (Walsh and Thijssen, 2015; ATA, 2015; MoA, 2015). As in many other developing countries, the supply of seed from the formal sector in Ethiopia is very limited and most smallholder farmers rely heavily on the informal seed system. For potato as a vegetatively reproduced crop, this increases the risk of using seed tubers with poor physical, physiological and genetic qualities and the spreading of seed- and soil-borne diseases (Gildemacher *et al.*, 2009; Hirpa *et al.*, 2010; Thomas-Sharma *et al.*, 2016). In addition, the informal farmer-to-farmer seed potato sharing may not always give equal access to farmers of different socio-economic status (Tadesse *et al.*, 2016). In this context, community-based seed production is promoted as a complementary strategy that serves the dual purpose of improving seed quality[1] and seed system efficiency (Schulz *et al.*, 2013; FAO and ICRISAT, 2015).

While in profitable cash-generating activities like coffee and dairy production the producer organisation bundles the efforts of farmers to foster effective value chain participation (Kodama, 2007; Chagwiza *et al.*, 2016), in seed production, the principal reason to promote collective efforts stems from the failure of the public sector to arrive at a sustainable seed sector that provides farmers with quality seed of improved varieties, the Ethiopian potato seed

[1] Seed quality refers to "attributes of the seed tuber that affect its value: genetic purity, physical condition, health condition and physiological age" (Thomas-Sharma *et al.*, 2016).

sector being a case in point (Hirpa *et al.*, 2010). Currently, decentralization and private sector participation are presented as effective strategies to increase availability and access of quality seed to smallholder farmers (Scoones and Thompson, 2011; Louwaars and De Boef, 2012). Farmer groups, cooperatives and other forms of community seed production are seen as sitting in between formal and informal seed system, being able to bridge the traditional with the commercial seed supply (FAO and ICRISAT, 2015). In addition to decentralization of the multiplication of seed, also alternatives to the quality control are explored. In most countries, seed certification is a service provided by the public sector: its centralized nature and the complicated logistics – especially in the case of bulky and perishable vegetatively propagated crops like potato – renders the certified seed as too expensive for most smallholder farmers. It is against this background that we studied the experiences of two potato seed cooperatives in Chencha *Wereda*, Southern Nations, Nationalities and Peoples Regional State (SNNPR), Ethiopia.

In spite of many initiatives to set up community or farmer-group based seed production, there is little empirical evidence about the group functioning in producing and marketing quality seed (FAO and ICRISAT, 2015). For potato seed production in Ethiopia, Oumer *et al.* (2014) showed how potato seed production empowered female farmer groups. Abebe *et al.* (2010) studied the economic advantages of two seed potato cooperatives in comparison to two ware potato cooperatives. In our study we were interested in the way a group of farmers were able to engage in quality potato seed production and marketing. We were particularly interested in how collective action by a group of farmers combines with efforts to maintain seed quality.

This paper presents the experiences of two young seed potato cooperatives in the Chencha *Wereda*. The paper describes how seed cooperatives functioned around seed potato production and marketing with the support from an Ireland-based Non-Governmental Organization (NGO), Vita, and analyses how the farmer groups were organised, how they produced, kept up quality and marketed their potato seed. The paper discusses the implications for decentralised quality seed supply.

Study site and project context

The study was conducted in the Chencha *Wereda*, located almost entirely in the highlands of the Gamo Gofa Zone of the SNNPR, Ethiopia. Crop cultivation and livestock rearing are the dominant economic activities. The main crops are wheat, barley, potato, enset (*Ensete*

ventricosum) and apple. Chencha *Wereda* has good potential for both ware and seed potato production (Mazengia *et al.*, 2015) but the average potato yield is very low at 2.4 t/ha (Mesfin *et al.*, 2014). Households engage in various off-farm activities (weaving, selling wood and labour) for a complementary income.

Vita aims to support local communities in Chencha to increase farm income and food security. The NGO supported the establishment of two potato seed cooperatives in 2010 as part of a larger potato project that aimed to (1) strengthen potato farmers' productive capacity and (2) improve access to market and to agricultural services in general and 3) access to improved potato seed in particular. The project organized farmers in groups for training in potato seed production. By working together farmers would be able to label their seed and become active participants in seed distribution channels. This would contribute to making quality seed more available and affordable for other farmers in and around Chencha. An underlying assumption was that peer learning and peer pressure among farmers would improve seed quality. Farmers were predominantly producing for home consumption and had little experience with a market-oriented production. A particular challenge was the recently discovered presence of bacterial wilt (*Ralstonia solanacearum)* in the area. Bacterial wilt is a highly contaminating seed- and soil-borne disease that limits potato cultivation causing heavy crop losses (Ajanga, 1993; Bekele *et al.*, 2011).

Data collection and analysis

Two potato seed cooperatives, known as Yoyera and Gendo Gembella, were studied in three phases between January 2013 and May 2015. The first phase (January, May and August 2013) studied the history and functioning of the cooperatives. It consisted of six exploratory interviews with cooperative members and for each cooperative focus group discussions were held with the executive committee (n=7 each) and with the quality assurance and controlling committee (n=3 each). For the second phase (March to October 2014) 48 members of the two cooperatives (24 members each) were asked about seed production and marketing experiences over the last four years, using a pre-tested semi-structured questionnaire. Members had been selected at random from the list of members provided by chair persons of each cooperative. In addition, six farmers whose seed lots had been rejected were interviewed. Complementary information was collected through group discussions with the quality assurance and controlling committees of the Yoyera (n=5) and Gendo Gembella (n=6) cooperatives, and attendance of several cooperative management meetings.

The last phase (February to May 2015) explored the effect of bacterial wilt incidence on the cooperative performance. For this purpose, two group discussions were held with members of the cooperative management, one in each of the cooperatives. Thirteen farms and 11 seed storages were visited to assess the incidence and management of bacterial wilt on-farm and in seed storages. The farm assessment included: the proportion of plants wilted, how members explain the reasons for wilting, and the type of actions taken by farmers for controlling the disease. Store inventory included estimating loss of seeds in storage and actions taken to minimize the loss. The specific plots were selected based on the discussion the first author had with members; plots were affected seriously with wilting.

All individual and group interviews, field assessment and store inventories on bacterial wilt incidence were recorded in audio and writing. Data collection and analysis were inter-woven right from the first phase of data collection.

Results

Functioning of the cooperatives

The Yoyera and Gendo Gembella cooperative both started out in 2010 with 30 members who were identified and invited by the NGO staff in collaboration with *Wereda* Cooperative Office. In each cooperative, members lived in the same local community, implying that many of them were family, friends or neighbours of each other. To become a member of the seed cooperatives, the NGO in collaboration with *Wereda* Cooperative Office had defined the conditions. A farmer had to be known as diligent and had to own at least 1.5 ha of land (relatively large in the Chencha context). In addition, a farmer had to be able and willing to pay an individual share of the cooperative (100 birr, equalling approximately €4) and sell the potato seed via the cooperative for cash. The NGO supported the construction of a Diffuse Light Storage (DLS), for which the farmer had to supply the local materials. In 2011, the NGO staff in collaboration with *Kebele* Administration staff identified 30 additional farmer-members for each cooperative. In 2013-2015, 11% and 8% of the members of the Yoyera and Gendo Gembella cooperatives were female farmers, respectively. In the group interviews, none of the participants qualified any of the members as poor. Farmers indicated that the basic reason for joining seed cooperatives was that membership provided them with better access to (1) financial and technical supports from different institutions, (2) high quality seed from first

generation seed producer cooperatives and (3) seed markets that were previously not accessible for them and which paid a better price than when seed was sold otherwise.

Both seed cooperatives were organised according to the recommendation of the NGO staff which followed the general format for cooperatives in Ethiopia as provided by the *Wereda* Cooperative Office. They both had five different committees, elected by the general assembly on the basis of one member one vote. The quality assurance and controlling committee was in charge of making sure the various committees and members performed according to the cooperative bylaws. The executive committee was responsible for the overall planning and implementation of all activities as well as for maintaining relationship between the cooperative and seed buyers. The remaining three committees were in charge of respectively credit, selling and purchasing.

In 2010, the experts from *Wereda* Cooperative Office had implemented 3-day training on cooperative concepts and management skills for all members. Within the last five years each cooperative had held two annual meetings and one financial audit. Meeting among executive committees and other committees was on an ad-hoc basis: whenever they felt they needed to meet and discuss. During fertilizer distribution and seed marketing they had frequent meetings in order to decide the amount of fertilizer to be purchased and distributed to the members, to look for market opportunities, and to decide on the price for seed and the amount of cash that had to be saved in the cooperatives' bank account after seed had been sold.

Seed potato production

In the first year of operation (2010), the NGO technicians provided each farmer-member with 500 kg of quality seed of the improved variety Gudene. Members also received intensive classroom and field training from the NGO staff on seed potato production practices. As part of the field training, members pooled all their labour and jointly practised the agronomic tasks in their production plots. This created an opportunity for learning and to undertake activities which the household might not easily do by its own, like land preparation and planting in ridges. At the same time, for the NGO staff it was a way of making sure the production practices of each member were in line with their recommended production and storage practices. In the same year, to build the cooperatives' financial capacity, the members produced seed potatoes on a common production plot and the money from the sold seed tubers was saved in the cooperative's bank account.

In the second year, the average quantity of seed tubers planted per member in both cooperatives was increased (see Figs 4.1 and 4.2). Both cooperatives had arranged an internal credit scheme where members could borrow cash for synthetic fertilizers without paying interest. The aim was to increase the members' fertilizer application. The credit schemes were the initiative from the executive committees. The financial sources were: registration fees (100 birr per member), selling seed potatoes planted on a common production plot and commercialized seed through the cooperatives (50 Birr per 100 kg of seed). The credit facility was open for all members. The request for credit was based on the amount of seed they were going to plant or to fill the gap they had in the amount of fertilizer they would apply. The support from NGO technicians continued through this second year, although less intensive. Pooling labour for cultivation activities on individual plots continued although farmers mentioned that the contributions from the members varied. The number of members who participated in the joint cultivation activities in the first year was higher than the number participating in this second year. There were also members who, once their plot was prepared, did not show up in the next joint labour activity. Participation of male members was also lower in plots owned by female farmers because they felt that the women's labour which they would get in return did not match the male labour contribution. In addition, members' number doubled while cooperatives had the same management capacity which made the organisation of the labour pooling more challenging.

In 2012, the NGO staff also arranged an exposure visit for some selected members and leaders of the two cooperatives to successful seed cooperatives in Jeldu area, near Holeta, to demonstrate advanced potato seed production practices, including the use of diffuse light storage and breaking dormancy. Application of these practices allowed two potato plantings per year. When visiting the cooperative in Jeldu, farmers were also able to note the success of the chairman. One attendant noted:

> "This man plants a large volume of seed potatoes by renting land. He has a truck and other businesses established because of seed potato. And he has employees to run the businesses. This means that if we work hard on seed potato we can diversify our means of livelihood."

How cooperatively farmers produced and disseminated quality seed potatoes was not part of the main lessons mentioned.

From the third year onwards, there was no more support from NGO staff. Each member produced potatoes on his or her own; pooling of labour had stopped because many of the members preferred to work individually. They also no longer jointly produced seed potatoes to generate capital for the cooperative credit fund.

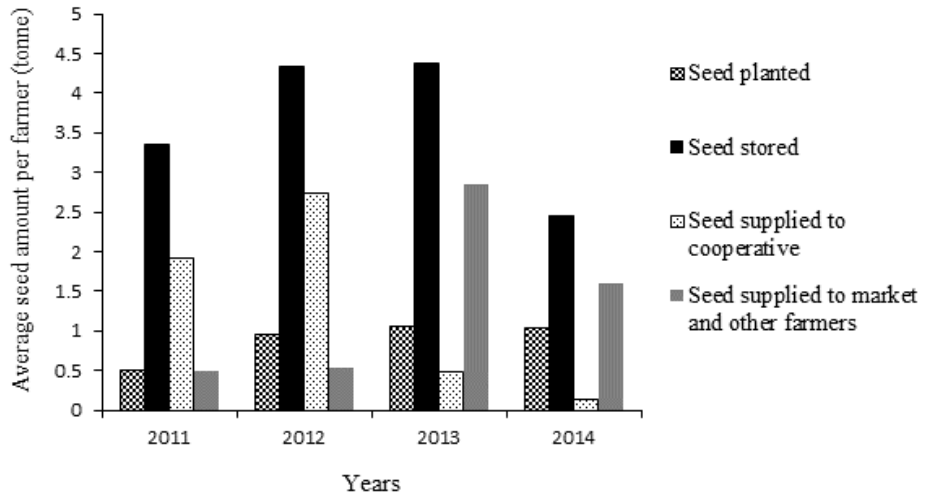

Fig 4.1. Seed production and marketing in Yoyera seed cooperative (n=24)

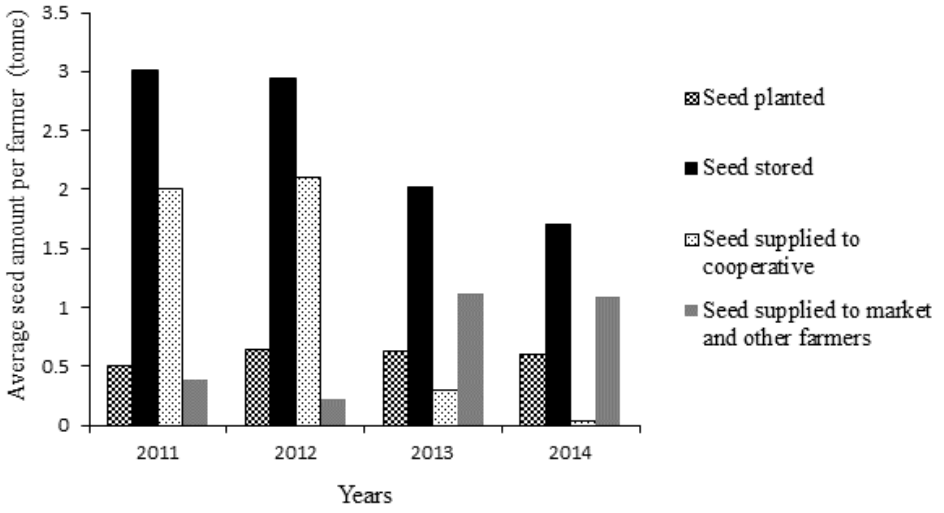

Fig 4.2. Seed production and marketing in Gendo Gembella seed cooperative (n=24)

Collective seed quality assurance

Both seed cooperatives had a quality assurance and controlling committee formed by the chairperson and two members. One of the responsibilities of the committee was inspecting the quality of the crop in field and of the seed in the stores. They also functioned as an intermediary between members and buyers. The committee members had been elected on the basis of their experience in different leadership roles in the community. According to the members of the two quality assurance and controlling committees, there were no specific criteria defined for rejecting a seed crop in the field or seed lot in store. The committee members also did not have special training or written manuals that supported their activities. They directly and indirectly checked the tillage frequency, previously planted crops, and disease incidence in a seed potato crop (at flowering stage) and in storage. With regard to bacterial wilt, the committee members said they rejected a seed lot when the number of wilted plants in the field at the time of flowering was "large", plants with symptoms of bacterial wilt were close together or when the wilting continued after sanitation measures had been taken. If the wilted plants were widely separated (10-15 m), they recommended a sanitation measure: removing the wilted plants from the field was thought to be able to save the crop. The up-rooted infected plants were mostly disposed along the hedges of the field (personal observation of the first author). Farmers were not asked to up-root plants around the wilted plants if they were quick in removing the wilted plants and wilting did not continue. If wilted plants were close to each other, the plot was to be rejected as a source for seed because it was considered that neighbouring plants would very likely be infected as well. The committee members normally shared their decision with the farmer-member at the end of their inspection visit.

In the first two years, the quality assurance and controlling committees of Yoyera and Gendo Gembella seed cooperatives rejected the seed lots of respectively seven and ten members. The reasons were that more than half of the crop was wilted, and/or tubers were too large and had cracks. None of the farmers was compensated for the seed rejected because compensation was not part of the bylaw and the cooperatives did not have sufficient financial capital to do so. As mentioned by the quality assurance and controlling committees, a third reason was that they expected when members knew they would be compensated, they might not give sufficient attention to the quality of their seed production. Farmers with rejected seed lots were not happy with the decisions of rejection. One member who saw his seed crop rejected explained:

> "When I benefit, the cooperative also benefits. But, for some reason the cooperative overlooks the loser. To pay back the credit I took for buying fertilizer and new seed, I was forced to sell my sheep."

For the quality assurance and controlling committee, the process of seed quality assurance was not easy and visiting each plot demanded a lot of time. Sometimes they had to seek support of other members to accomplish their tasks. In addition, the committee members reported:

> "Taking decisions after observing a seed plot is not simple. It makes one feel bad when a seed plot needs to be rejected or accept it while the quality is poor. It is very hard to have clean seed and friendship going together."

In Gendo Gembella, all rejections were plots or seed lots in which a major portion of the crop was found infected by bacterial wilt. At the time of marketing, however, some of these farmers selected and supplied seed to the cooperative that they thought was healthy. According to the farmers, they supplied seed from rejected plots to recoup part of the money they invested in the production. "It was difficult for us to go further than this because we are living together," the committee stated. Other members were aware and afraid this could affect their future market opportunities due to poor performance of the seed in the new places. In 2013 and 2014, the incidence of bacterial wilt increased. In 2014, 16 out of 60 members of Gendo Gembella lost a major portion of their potato seed crop. Based on the advice from the executive committee, they immediately sold what they harvested as ware potatoes. There was however no formal decision communicated to the members who saw no bacterial wilt incidence in their fields. These members complained about the lack of follow-up actions on bacterial wilt management either by the executive committee, NGO staff or *Wereda* Agriculture Office.

Seed marketing

After harvest, the cooperative's chairman, secretary and treasurer set the price at which the cooperative members would sell their seed, based on their information about the price for improved seed in the nearest local market found in Chencha town. These three men also had the mandate of looking for potential buyers. Once buyers were identified, farmer-members carried or transported their seed by horse to an agreed place. Each member had equal share of

the total amount of seed to be sold: the total amount of seed requested by institutional buyers was divided to the total number of members who were ready to sale seed through the cooperative. NGOs and Agriculture Offices in the nearby *Weredas* were the main potato seed buyers. The *Wereda* Ministry of Agriculture would in most cases function as a broker.

In the first year, all except five of the members in both cooperatives sold a major portion of their produced seed via the cooperative. The five farmers were in urgent need for cash while the cooperatives needed time to finish transactions with the buyers. Finding buyers for the seed was not difficult, because of the brokering by the NGO. Also the price resulted to be very attractive. In the second year, all members supplied the major portion of their seed to the cooperatives. Data from interviews indicated that the average amount of seed sold to cooperatives increased from 1.9 to 2.7 tonne and from 1.9 to 2.1 tonne in the Yoyera and Gendo Gembella seed cooperatives, respectively (Figs 4.1 and 4.2). The higher price that farmers got for the seed had been their main motivation to sell through the cooperative. The buyers were essentially the same ones as the previous year, and contact was facilitated through the NGO. The good prices and good yields because of the improved production technology contributed to the household income and enabled farmers to move to a new house with a roof covered by iron sheet, cover school expenses for their children, and start operating small businesses.

Financial (mis)management

In 2013 and 2014, members significantly reduced the amount of seed they sold through the cooperatives. Farmers referred to the mismanagement of the cooperative money as a reason. In 2012, for instance, many farmers in the Yoyera cooperative had not received the full payment for the seed they sold through the cooperative. They lost from 1,800 to 6,000 Birr per farmer. One of the female farmers explained:

> "Last year, when I requested the remaining money (6,000 Birr) the response from the chairperson was totally discouraging. The chairperson was hiding himself from members. This year I supplied only 100 kg of seed. I do not want to lose my membership. But I also do not want to lose more money".

The financial mismanagement made the members of the management committee very uncomfortable. Eventually, the cashier asked the *Wereda* Cooperative Office to assess the

accuracy of the recorded financial accounts. The audit report did not, however, bring out the full picture. Members were not able to challenge the audit procedures, resulting in a further decline of members' confidence in accounting procedures. Finally, the cashier resigned, but the other members in different committees remained in place.

In the case of the Gendo Gembella, the main reasons for reducing the amount of seed sold through the cooperative during the last two years were bacterial wilt and lack of commitment among leaders. Farmers with seed plots infected by bacterial wilt were forced to sell their crop as ware potatoes immediately after harvest. Farmers who produced seed free from bacterial wilt could not access the market through the cooperative because the cooperative leaders did not try to find buyers. There was however no formal communication on the decisions of the cooperative leaders. At the time of submitting this publication, mid 2017, the Gendo Gembella cooperative has suspended its seed production and selling activities. Yoyera cooperative is still commercializing seed potatoes with the same management committee in place.

Discussion

Interventions by outside actors that aim to support farmers in organising themselves in a cooperative in order to access market and reap benefits from pooling resources continue to be broadly advocated. Also in the context of Chencha and potato seed production it was a logical strategy to engage smallholder farmers into a high-quality potato-seed market. Bringing together 30 farmers and adding 30 more one year later, providing them training in potato agronomy and cooperative management of activities was initially successful for both cooperatives. The commercialisation of quality seed brought substantial economic benefits to the cooperative members. However, the support during the first two years was not sufficient to sustain the proper functioning of both cooperatives, which negatively affected the quality of seed. It is important to reflect on the experiences of these two cooperatives in order to understand the potential of farmer cooperatives in general, and decentralised seed production groups in specific.

The membership criteria did first of all result in relatively well-to-do farmers composing the cooperative. These farmers had better land holding and financial capacity in that they could produce seed potato by hiring labour and could market their seed from home or in the local market. For them, the attractiveness of jointly working on the land was not obvious. Their

other experiences with potato seed production also did not point to the importance of collective action. During the exposure visit of the cooperative near Holeta, cooperative leaders saw the apparent success of cooperative members who had diversified their business with use of the profit made on the selling of seed potatoes. The need to work together to achieve such success was not so obvious. In addition, in the first years of the seed production initiative there was not an existing market or effective demand for the seed: nobody knew about the initiative and farmers normally used their own on farm saved seed. The NGO functioned as a broker: it did the promotion, sought buyers and their support to the cooperative group was for the buyer (often another development project) a guarantee for the seed quality as well. As a result, in the first two years they sold all the seed they had produced without much effort and for good prices. This led them to question the value of going through the cooperative structure with the associated procedures and delays in payments. This might also negatively influence their initiative and commitment to cooperation. In the meantime, some name for potato seed from Chencha already established, individual commercialisation on the local market became an easy attractive alternative.

Maintaining high level of seed quality represented a major challenge to the two cooperatives. In this respect, potato seed multiplication is quite challenging and requires knowledge, well developed infrastructure (storage, transport) and a high level of collective discipline to control seed- and soil-borne diseases. In this case, the outbreak of bacterial wilt (*Ralstonia solanacearum)* resulted in a rather unexpected high pressure on the farmer cooperative groups, adding to the more common pressure of virus diseases and late blight (*Phytophthora infestans*). The inspection committees were not sufficiently staffed and trained to assess seed plots during flowering and follow up on the stored seed lots. There was no specific manual on quality assurance. It also resulted that the bylaws had no provisions for issues associated with seed production and seed quality maintenance. There were no threshold values for number of diseased or wilting plants in the field or affected tubers in storage that the quality assurance and controlling committee should apply. No rules existed for the disposal of rogued plants, nor were there rules formulated in relation to financial compensation for the affected producers. The elimination of low quality seed lots is crucial to maintaining the seed quality and is in the long run important for the reputation of a seed cooperative. However, if this importance is not well understood and rules are not clear, the elimination of low quality seed lots affects social relations and puts pressure on the solidarity among the members. By the time these became important issues for the cooperatives, the support from the NGO project

had ended, and the *Wereda* Cooperative and Agricultural Offices did not offer solutions either.

Eventually, for proper functioning of cooperatives, the enforcement of decisions of management committees and democratic processes through annual meetings of the members need to be guaranteed. Although the bylaw of the cooperatives clearly stated that the annual meeting was an obligation, these meetings were not held. In the Yoyera and Gendo Gembella cooperatives, there were no regular meetings between different committees and among all members. As a result, there was no space for members to demand change of leadership and claim for the prescribed elections or audits. This case confirms the importance of participatory and democratic governance in building trust among the new generation of producer organizations as argued by Shiferaw *et al.* (2011).

Conclusions and implications

The case studies showed that the cooperative capacity to supply clean quality potato seed was not sustainable. It is not only the crop growing and storage practices that are important to maintain seed quality, but also the knowledge and discipline in the quality control. These elements are basically part of an education process through which farmers learn how to produce better quality seed, recognize and understand the expression and spread of the locally important diseases (Thapa *et al.*, 1999). The experiences of the cooperative reported in this study show that seed quality management go beyond following technical knowledge and prescriptions: it requires collective action. Collective action asks not only technical capacity but also social capacity. Competent and committed leaders who have the capacity for organizing and leading group efforts are highly important (Ortmann and King, 2007). These can be partly captured in good rules and regulations of the cooperation. However, in our case, these rules were not available on the inspection of plots and storages, nor for compensation of rejected seed lots. In a similar vein, the rules of cooperatives may be well described, but as long as they cannot be enforced, they are not functional either. Thus, cooperative production and maintenance of quality seed asks for a long-term approach, which continually engages in diagnosis of what the relevant material and social problems are, and responding to changes and new challenges occurring.

Tension between the need to maintain high level seed quality and the collective action of members gets even more importance in the light of discussions around alternative seed quality

regimes, like Quality Declared Seed and mechanisms based on "branding". Formal seed certification is constrained in situations where seed production is highly centralised and thus, less formal and less costly mechanisms are proposed. This would leave the responsibility of seed quality control largely in hands of seed producing groups themselves. When farmer groups would be able to do so technically, it is not sure that they will be able to do it socially. This springs the need to understand community level dynamics and how interests of farmers can be accommodated and represent a threat to group initiatives. Eventually, the success and failure of these initiatives are not without consequence: in the case we reported on, the spreading of bacterial wilt with the diffusion of contaminated potato seed beyond seed tuber producing areas has already been proven (Abdulrahman *et al.*, 2017).

References

Abdurahman, A., Griffin, D., Elphinstone, J., Struik, P. C., Schulz, S., Schulte-Geldermann, E., and Sharma, K. (2017). Molecular characterization of Ralstonia solanacearum strains from Ethiopia and tracing potential source of bacterial wilt disease outbreak in seed potatoes. Plant Pathology 66: 826–834.

Abebe, G.K., Bijman, J., Ruben, R., Omta, O., and Tsegaye, A. (2010). The role of seed/ware potato cooperatives in Ethiopia in improving quality and reducing transaction costs. Paper Presented at the 9th Wageningen International Conference on Chain and Network Management, 26–28 May 2010, Wageningen, The Netherlands.

Ajanga S. (1993). Status of bacterial wilt of potato in Kenya. In: Hartman G.L. and Hayward A.C. (Eds.). Bacterial wilt, ACIAR Proceedings, Canberra 45: 338-340.

ATA (Ethiopian Agricultural Transformation Agency) (2012). Agricultural cooperatives sector development strategy 2012–2106. Addis Ababa: ATA.

Bekele, B., Abate, E., Asefa, A. and Dickinson, M. (2011). Incidence of potato viruses and bacterial wilt disease in the west Amhara sub-region of Ethiopia. Journal of Plant Pathology 93(1): 149-157.

Bernard, T., Spielman, D.J., Taffesse, A.S., and Gabre-madhin, E.Z. (2010). Cooperatives for Staple Crop Marketing: Evidence from Ethiopia. International Food Policy Research Institute Research Monograph 164.

Brass, T. (2008). How agrarian cooperatives fail: Lessons from 1970s Peru. The Journal of Peasant Studies 34(2): 240-287.

Chagwiza, C., Muradian, R., and Ruben, R. (2016). Cooperative membership and dairy performance among smallholders in Ethiopia. Food Policy 59: 165-173.

Desta, E. (1995). Agricultural producer cooperatives: some lessons of experience from Ethiopia. GeoJournal, 36: 353-360.

FAO and ICRISAT. (2015). Review of community seed production practices in Africa Part 2: lessons learnt and future perspective. In: Ojiewo, C.O., Kugbei, S., Bishaw, Z. and Rubyogo, J.C. (Eds.), Community seed production, Workshop proceedings, 9-11 December 2013, 29-38, FAO, Rome and ICRISAT, Addis Ababa.

Francesconi, G.N. (2008). Cooperation for competition linking Ethiopian farmers to markets. PhD Thesis, Wageningen: Wageningen Academic Publishers.

Getnet, K. and Anullo, T. (2012). Agricultural cooperatives and rural livelihoods: evidence from Ethiopia. Annals of Public and Cooperative Economics 83(2): 181–198.

Gildemacher, P.R., Kaguongo, W., Ortiz, O., Tesfaye, A., Woldegiorgis, G., Wagoire, W.W., Kakuhenzire, R., Kinyae, P.M., Nyongesa, M., Struik, P.C., and Leewis, C. (2009). Improving potato production in Kenya, Uganda and Ethiopia: A system diagnosis. Potato Research 52: 173–205.

Hirpa, A., Meuwissen, M.P.M., Tesfaye, A., Lommen, W.J.M., Oude Lansink, A., Tsegaye, A. and Struik, P.C. (2010). Analysis of seed potato systems in Ethiopia. American Journal of Potato Research 87: 537-552.

Kodama, Y. (2007). New role of cooperatives in Ethiopia: the case of Ethiopian coffee farmers cooperatives. African Study Monographs 35: 87–108.

Louwaars, N., and de Boef, W. (2012). Integrated seed sector development in Africa: a conceptual framework for creating coherence between practices, programs, and policies. Journal of Crop Improvement 26: 39–59.

Mazengia, W., Schulte, R., Tadesse, Y., Griffin, D., Schulz, S., and Struik, P.C. (2015). The farming systems of potential potato production areas of Chencha, Southern Ethiopia. In: Low, J., Nyongesa, M., Quinn, S. and Parker, M. (Eds.), Potato and sweet potato in Africa: Transforming the value chains for food and nutrition security. CAB International: London, UK, pp. 382-395.

Menza, M., Girmay, G., and Woldeyes, F. (2014). Enhancing household food security through Irish potato production in Gamo Highlands of Southern Ethiopia. Scholarly Journal of Agricultural Science 4: 410-419.

Oumer, A.M., Tiruneh, W.G., and Tizale, C. Y. (2014). Empowering smallholder women farmers through participatory seed potato management: lessons from Welmera District, Ethiopia. Journal of Sustainable Development 7(5).

Ortmann, G.F. and King, R.P. (2007). Agricultural cooperatives II: Can they facilitate access of small-scale farmers in South Africa to input and product markets? Agrekon 46(2): 219-244.

Scoones, I., and Thompson J., (2011). The politics of seed in Africa's Green Revolution: Alternative narratives and competing pathways. IDS Bulletin 42(4): 1–23.

Schulz, S., Woldegiorgis, G., Hailemariama, G., Aliyi, A., Haar, J. van de, and Shiferaw, W. (2013). Sustainable seed potato production in Ethiopia: from farm-saved seed to quality declared planting material. In: G. Woldegiorgis, S. Schulz, B. Berihun (Eds.), Seed potato tuber production and dissemination: Experiences, challenges and prospects. Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute, pp. 60-71.

Shiferaw, B., Hellin, J. and Muricho, G. (2011). Improving market access and agricultural productivity growth in Africa: What role for producer organizations and collective action institutions? Food Security 3: 475–489.

Tadesse, Y., Almekinders, C.J.M, Schulte, R.P.O. and Struik, P.C. (2016). Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. Experimental Agriculture doi:10.1017/S001447971600051X

Thapa, B., Ojha, D.N., Saha, B. and Hidalgo, O.A (1999). Manuals to guide seed producer group for the implementation of rules and regulations for seed potato quality control. Potato research program/project, CIP/SDC, Khumaltar, Lalitpur, Nepal. 17p.

Thomas-Sharma, S., Abdurahman, A., Ali, S., Andrade-Piedra, J. L., Bao, S., Charkowski, A. O., Crook, D., Kadian, M., Kromann, P., Struik, P. C., Torrancei, L., Garretta, K. A. and Forbes, G. A. (2015). Seed degeneration in potato: the need for an integrated seed health strategy to mitigate the problem in developing countries. Plant Pathology 65(1): 3-16.

Walsh, S., and Thijssen, M.H. (2015). Programme on integrated seed sector development in Ethiopia. Annual Report. Wageningen University and Research - Centre for Development Innovation, Bahir Dar University, Hawassa University, Haramaya University, Mekelle University and Oromia Seed Enterprise. Report CDI-16-012. Wageningen.

World Bank (2007). World development report 2008. Agriculture for Development. Washington, DC, World Bank.

CHAPTER 5

Potatoes and livelihoods in Chencha, southern Ethiopia

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Abstract

Potato is highly productive and can provide a cheap and nutritionally rich staple food. Its potential as a cash generator and source of food is much under-utilised in many emerging economies. In this paper we study an intervention that introduced improved potato technologies in Chencha, Ethiopia, and explore its role in improving the livelihoods of smallholder farmers. We collected data through in-depth interviews and a household survey. The results show that changes in agronomic practices and consumption were most pronounced among wealthy farmers who participated in the intervention. Farmers in different wealth categories used the additional income from potato in different ways: wealthier farmers improved their houses and increased their livestock, whereas poor farmers mainly invested in household equipment and developing small businesses. Some farmers who did not participate in the project also derived some indirect benefits from the intervention, although these were mostly wealthy farmers. The findings show that the positive effects of the intervention largely depended on existing farm resources and households' priorities. This underscores: i) that farming technologies in themselves are not always sufficient to improve the livelihoods of poor farmers and ii) the need to broaden the scope of interventions so as to take into account the resources available to farmers in different wealth categories, and the diversity of strategies that they employ for improving their livelihoods.

Introduction

Despite long-term efforts to increase agricultural productivity in Ethiopia the country remains a net importer of food in order to meet domestic demand. Increasing population pressure, diminishing farm sizes, the depletion of soil organic matter and soil nutrients, soil erosion, highly variable rainfall, and underdeveloped food-producing resources that are heavily reliant on low-input farming practices are undermining the efforts to increase agricultural productivity (Winer, 1989; Asefa, 2003; Negatu, 2008; Bogale, 2012). Eighty-five per cent of the country's population depends on farming for a living and much emphasis is placed on technology-led initiatives as a means of reducing food insecurity (Araya, Keesstra and Stroosnijder, 2010; Beyene, 2008; Bogale, 2012). The promotion of improved potato varieties and of new production technologies for smallholder farming systems are central elements of attempts to improve agricultural productivity (Tesfaye, Woldegiorgis & Kaguongo, 2013).

The discussion around the role and potential of potato in Ethiopia is dominated by four central assumptions:

- potato is an integral part of smallholder farming systems as it has been grown and consumed for about a century;
- potato has a short cropping cycle, is highly productive and can be harvested before cereal crops mature;
- potato provides a cheap and nutritionally-rich staple food; and
- the potential of potato as a cash and food crop is greatly under-utilised (Scott *et al.*, 2000; Sen *et al.*, 2010; Woldegiorgis *et al.*, 2015).

The contribution of potato to households' food consumption has recently received much attention. For instance, the United Nations declared 2008 as "The International Year of the Potato", drawing global attention to the important role of this nutritious plant (FAO, 2008). Many see potato as having a crucial role in guaranteeing household food consumption due to the cheap price it has, as it is mainly traded at the national level, with the price usually determined by local (as opposed to global) production costs (Scott *et al.*, 2000; FAO, 2008; Cromme *et al.*, 2010; Woldegiorgis *et al.*, 2015). However, the potential of potato as a tool for stimulating agrarian change depends upon improving potato production and productivity,

through the adoption of high quality seed potato, good management practices, proper post-harvest handling and the availability of suitable storage facilities (Demo *et al.*, 2015).

This paper explores the initial effects of an intervention that recently started to promote improved, high-yielding and disease-tolerant potato varieties and improved management practices in Chencha *wereda*, southern Ethiopia. It provides an example of an intervention that claims to have potential of improving the livelihoods of smallholder farmers. In analysing the effects of this intervention we asked the following questions:

- What changes have occurred in households' farming practices since the start of the intervention?
- What differences have these changes made to households' livelihoods?
- Do such changes and differences apply equally to farmers in different wealth categories?

Materials and methods

Background: the study site and project intervention

The Chencha *wereda* is located in the Gamo Gofa Zone of the Southern Nations, Nationalities, and Peoples Region, Ethiopia. Farmers in the *wereda* of Chencha grow a range of crops, including potato, enset, wheat, barley and kale, and raise livestock (cow, ox and sheep). The bi-modal rainfall includes a *Belg* (the short rainy season from March to May) and a *Meher* (the long rainy season from June to October) season and allows two potato planting seasons (Mazengia *et al.*, 2015).

The non-governmental organization Vita, based in Ireland and active in Eastern Africa, is engaged in different development activities to enhance families' food, energy and water security and to support the efforts to build sustainable livelihoods. The introduction of improved potato technologies is core to Vita's agricultural development programme in southern Ethiopia. In 2013, it introduced an intervention to disseminate new potato varieties among 360 farmers, 260 ware producers and 100 seed producers, who received 250 kg and 625 kg of seed potatoes for each, respectively. These farmers were also trained in improved potato production practices: the application of synthetic fertilizers, land preparation, ridge planting, land preparation, weeding, disease management, harvesting and storage. In addition, 24 out of 260 ware producers and all of the seed producers were provided with construction materials to better store

ware and seed potatoes post-harvest. It was intended that this intervention would: i) make quality potato seed more widely available in the area; ii) improve potato productivity at the level of the individual farms and the participating communities; iii) reduce the duration of the 'hungry period', and; iv) increase household incomes. The assumption was that the benefits derived from this intervention would be powerful enough to improve the livelihoods of farmers in Chencha.

Data collection and analysis

The data collection focused on four *kebeles* in Chencha: Yoyera, Gendo Gembella, Losha, and Laka. It was done in two parts: a series of exploratory interviews, followed by a larger scale survey. In February - March 2015, 20 randomly selected farmers who had received materials and training from Vita were interviewed with the support of a translator whenever necessary. The interviews explored four main areas: potato cropping practices prior to the intervention; the amounts harvested and uses to which they were put; the support provided by the intervention; and improvements attributable to the intervention. These interviews helped us to identify a range of indicators of the effects of the intervention at a household level. The first-named author conducted the interviews in Amharic, which were audio-recorded and transcribed into English.

In April 2015, we randomly sampled 140 farmers who had participated in the project and 64 farmers who had not. We used lists of names of those who did and did not participate in the project, as registered by the administration of each *kebele*. Participants had direct access to the materials and training provided by the project, while non-participants only had indirect access, if at all. Enumerators used a questionnaire to collect information from the sample of farmers. The questionnaire focused mainly on the changes following the project intervention: change in potato production practices and livelihoods of the farmers. To categorize the surveyed households by wealth status, we convened focus groups and discussions in the four *kebeles*, in each of which a sample of 7-10 community members participated. To differentiate between relatively wealthy, medium-wealthy and poor farmers, participants identified the following key criteria: size of land holding; number of livestock; house structure (floor area and construction materials) and number and age of enset (*Ensete ventricosum*) plants. On this basis the participating group contained 27 wealthy, 92 medium-wealthy and 21 poor farmers (circa 20%, 65% and 15%, respectively) and the non-participating group 21 wealthy, 25 medium-wealthy and 18 poor farmers (circa 33%, 39% and 28%, respectively).

We used descriptive statistics to process the household survey data. Log-linear analysis (χ^2) was used to test the association between participation in the intervention, farmers' wealth category and changes in households' livelihoods. Odds ratio was computed to determine the effect of participation in the intervention on the livelihoods for the three wealth categories using the SPSS version 22® (Field, 2009). To triangulate these results we occasionally use respondents' quotes from the in-depth interviews.

Results

Changes in agronomic practices

Wealthy farmers were more likely to adopt more improved practices (six out of seven) than medium-wealthy (who adopted five practices) and poor ones (three). This applied among both participant and non-participant farmers (Figs 5.1, 5.2 and 5.3), although those in direct receipt of the improved varieties and management practices adopted significantly more new practices (Table 5.1). Medium-wealthy farmers who received the extension adopted the new cropping practices almost as often as wealthy farmers, except for fertiliser application and ware potato storage, the latter of which was quite poorly taken up among all wealth categories. Poor farmers adopted fewer of the new practices: new varieties, tilling and triple weeding being the most widely adopted. Some poor farmers who did not participate in the project (28%) did adopt the new varieties and practices of tilling and weeding more frequently. Those we interviewed said that local market and farmers in the neighbourhood were the sources for the new varieties. They have learned the new cropping practices from farmers in the neighbourhood, mainly as a result of being hired to do these jobs. Wealthy non-participant farmers who adopted some of the new practices (57%) said that they learned by observing what others were doing.

Increased commercialization

Before the intervention, 79% of participating farmers said that they only produced for home consumption (Fig. 5.4). After the intervention, only 26% produced solely for home consumption and 74% were selling seed or ware potatoes in the local markets. Non- participant farmers mainly grew potato solely for domestic consumption; although there was also a shift here towards greater commercialization after the intervention (just 7% sold potatoes before the intervention and 27% afterwards). None of the respondents grew potato solely for cash (Fig. 5.4). The shift towards partial commercialization because of participation in the intervention

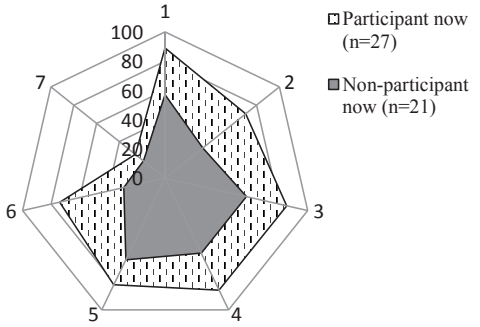

Fig. 5.1. Adoption of improved varieties and agronomic practices among wealthy farmers (%)

Log-linear analysis (χ^2): wealthy participant vs non-participant: 1 = 6.35*; 2 = 6.52*; 3 = 4.70*; 4= 4.70*; 5=2.29; 6=9.85**; 7=0.316

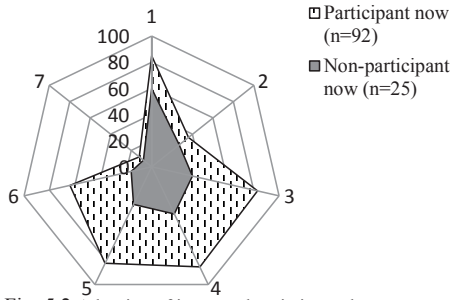

Fig. 5.2 Adoption of improved varieties and agronomic practices among medium-wealthy farmers (%)

Log-linear analysis (χ^2): medium-wealthy participant vs non-participant: 1=7.40**; 2= 0.74; 3=24.86***; 4=21.14***; 5=3.38***; 6=18.32***; 7=1.00

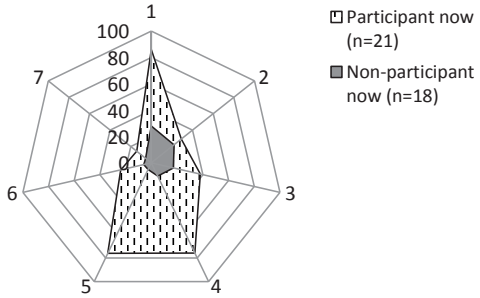

Fig. 5.3. Adoption of improved varieties and agronomic practices among poor farmers (%)

Log-linear analysis (χ^2): poor participant vs non-participant: 1= 13.44***; 2 = 0.20; 3=2.19; 4 = 16.51***; 5 = 19.66***; 6=2.48; 7= 0.803

Figures 5.1-5.3: Potato production practices and use of improved varieties among participant and non-participant farmers by wealth categories.

1 = improved potato varieties; 2 = synthetic fertilizers only; 3 = planting in ridges; 4 = tilling three times; 5 = weeding three times; 6 = improved seed storage; 7 = improved ware storage.

*,** and *** indicate significant effects at $p < 0.05$, $p < 0.01$, $p < 0.001$, respectively.

Table 5.1. The effect on potato production practices as the result of participating in the intervention for the three wealth categories

Production practices	Odd ratios		
	Wealthy (n=48)	Medium (n=117)	Poor (n=39)
Improved varieties	6.00	3.71	15.60
Synthetic fertilizers	4.75	n/a[#]	n/a
Planting in ridges	4.31	10.09	n/a
Tilling three times	4.31	8.36	25.6
Weeding three times	n/a	9.38	54.40
Seed storage	7.14	9.39	n/a
Ware storage	n/a	n/a	n/a

[#] Not applicable as the association is not significant

was more pronounced among wealthy farmers (13.71) than medium- wealthy and poor farmers (3.61 and 7.27, respectively) (Fig. 5.4). Farmers said that the shift towards commercialization was due to higher yields resulting from use of the new variety and production practices and receiving good prices for the new improved varieties of potato (both as ware and seed). Around half of the wealthy farmers (13 out of 27) were selling some potato on local markets before the project, and they substantially increased the volume of potato they supplied to the local market, from an average of 338 kg to 1,546 kg. One of the wealthy participating farmers, said: "Selling such a big volume of seed potato is a new experience for me. Now, next to apple, potato has become an important means of income for my family."

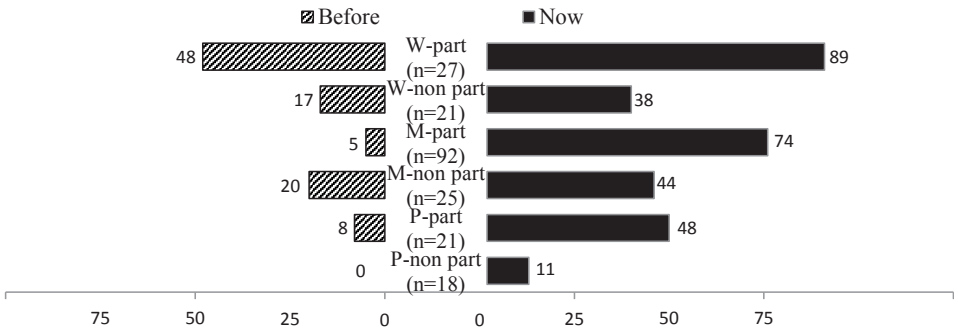

Fig. 5.4. Farmers commercializing part of their potato harvest (%)
Wealthy - $\chi^2 = 13.71^{**}$, Odd ratio (OR) = 13.0; Medium - $\chi^2 = 8.02^{**}$, OR = 3.61;
Poor - $\chi^2 = 6.06^{*}$, OR = 7.27

W = wealthy; M = medium; P = poor
Part = participant; Non-part = non-participant

Changes in livelihoods

The adoption of improved potato production technologies and increases in yields and incomes enabled many farmers to develop their financial and material assets. Among participating farmers, the average amount of seed and ware potato sold per year increased from 0.33 to 1.20 tonnes as a result of the intervention and among non-participating farmers it increased from 0.25 to 0.61 tonnes. As a result, the average income from potato almost doubled among participant farmers (range 600 to 5,000 Ethiopian Birr), and among non-participant farmers it increased by almost one third (range 350 to 3,400 Birr). Farmers in different wealth categories invested the cash earned from potato in different ways. Many wealthy and medium-wealthy farmers constructed new houses with corrugated iron. They used to live in their traditional

bamboo or grass rooves. Participating farmers in the two upper wealth groups were twelve times more likely to do this than their non-participating counterparts (Table 5.2). Similarly, these two groups of participating farmers were six times more likely than non-participants to increase their livestock. Wealthy farmers mostly acquired oxen or cows while medium-wealthy farmers mainly increased the number of sheep. Poor farmers adopted other strategies, mainly buying new household equipment or investing in small businesses and did so five and six times more (respectively) than their non-participant counterparts. The small businesses involved selling (and buying) cereals, weaving products and milk products in the local markets.

Not all income from potato was used for building tangible assets. The type of asset accumulation partially depended on the amount of cash gained from potato and household priorities. More than half of farmers (12 out of 21), who sold a relatively large amount of potatoes, prioritized sending their children to private college or paying back loans they had taken from other farmers. A medium-wealthy farmer stated that "The cash from potato enables me to pay college fees for my two children. When they graduate they will have independent lives. In the future, they will be able to support me." However, in some cases, the improved potato technology had a negative impact on assets. A number of medium-wealthy (13%) and poor (33%) participant farmers were forced to make additional expenses or to sell assets after their investment in seed and/or fertilizer failed to turn into a good potato harvest. A poor farmer

Table 5.2. The effect on assets as a result of participating in the intervention, by wealth category (%)

Asset	Wealthy		Medium	
	Participant (n=27)	Non-participant (n=21)	Participant (n=92)	Non-participant (n=21)
House construction	56	10	52	8
Log-linear (χ^2)	10.94***		15.67***	
Odds ratio	11.88		12.55	
Livestock	41	10	33	12
Log-linear (χ^2)	5.82*		4.12*	
Odds ratio	6.53		3.55	
Asset	**Medium**		**Poor**	
	Participant (n=92)	Non-participant (n=25)	Participant (n=21)	Non-participant (n=18)
Small business	20	24	43	11
Log-linear (χ^2)	0.23		4.82	
Odds ratio	n/a[#]		6.00	
Household equipment	24	20	62	22
Log-linear (χ^2)	0.17		6.20*	
Odds ratio	n/a[#]		5.69	

[#] Not applicable as the association was not significant

explained her experience as follows: “I planted 250 kg of seed potato as per the training I received. I purchased and applied fertilizers, although I am not used to doing so for potato. In the first two months, the crop was very promising. In the last month, however, majority of the crop wilted. It was a big loss for me”.

Changes in consumption

Many farmers did not produce sufficient food to last them all year round. During the *Belg* season, the food runs out in April and the shortages do not end until May. Farmers across wealth categories mentioned that by May they had often exhausted their home-produced supplies. In the *Meher* season, the food shortage starts in September and lasts until mid-November, with October to mid-November being the critical months. This is the time when the crops in the fields are not ready to harvest, the food from the previous *Meher* harvest is fully-depleted and very little remains from the *Belg* harvest. During these periods households make major adjustments in their food balance: reducing the number of meals per day, cutting back on quantities consumed per meal, and using less-favoured crops. For the majority of farmers, potatoes matured in June to July during the shorter (*Belg*) rainy season and in December to January in the longer *Meher*. One of the changes associated with improved potato production was to extend the potato consumption period by an average of 2.3 months. The extension ranged from 3.4 extra months for the wealthier participant farmers to 10 extra days for the poor non-participant farmers.

Before the project intervention in 2012, in May, when potato reserves from the *Meher* harvest were depleted most households consumed not-fully grown enset (*Enset ventricosum*). Most farmers prefer maize to not-fully grown enset, but do not produce maize themselves and have to purchase it from local markets. After the project intervention, a high percentage of participant farmers, across all wealth classes, increased their maize consumption, and cut back on their consumption of not-fully grown enset (Figs. 5.5, 5.6 and Table 5.3). This was because the higher income earned from the new potato technology and (in the case of poor farmers) petty trading enabled farmers to purchase the maize they required.

Before the intervention, during September to mid-November, *Plectranthus edulis* and potato were the main staples of household food consumption. After the project intervention, some wealthy farmers consumed less *Plectranthus edulis* (as they planted less), and all wealth categories increased their consumption of new potato varieties, preferred to *Plectranthus edulis*.

Wealthy and medium-wealthy participant farmers significantly increased their potato consumption (Table 5.3). The farmers associated the increment in potato consumption mainly with increased yields, although improved ware storage technology was also a factor for a few farmers; 26% of wealthy participants and 12% of medium-wealthy participants.

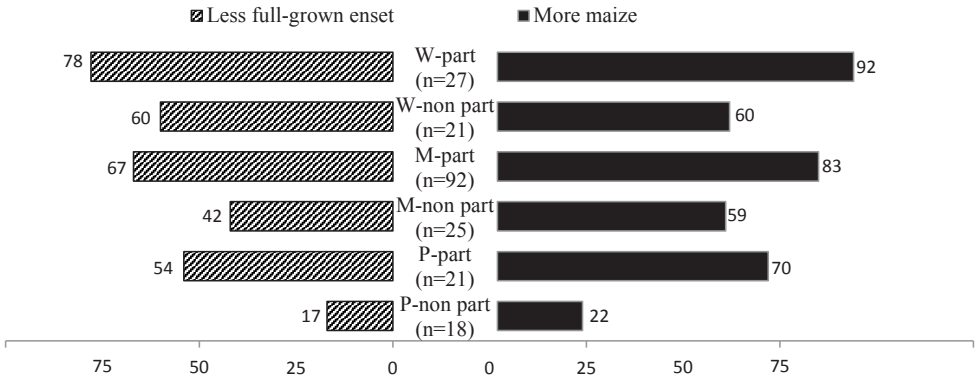

Fig. 5.5. Relative changes in crops consumed among participant and non-participant farmers by wealth class - May (%)

W = wealthy; M = medium; P = poor
Part = participant; Non-part = non-participant

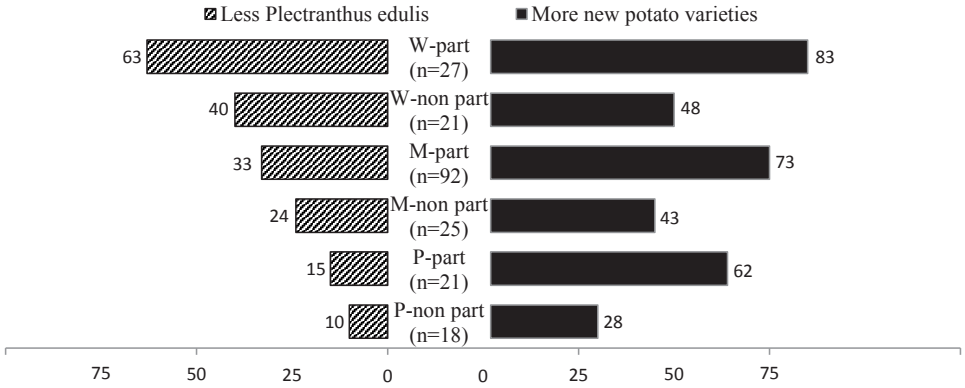

Fig. 5. 6. Relative changes in crops consumed among participant and non-participant farmers by wealth class - September to mid-November (%)

W = wealthy; M = medium; P = poor
Part = participant; Non-part = non-participant

Table 5.3. The effect on consumption patterns as a result of participating in the intervention

Attributes	Wealthy (n=48)	Medium (n=117)	Poor (n=39)
Less consumption of immature grown enset			
Log-linear (χ^2)	3.42	5.40*	5.37*
Odds ratio	n/a#	2.80	5.73
More maize consumption			
Log-linear (χ^2)	6.74*	5.81*	9.39**
Odds ratio	8.28	3.39	8.27
More consumption of new potato varieties			
Log-linear (χ^2)	6.09*	7.35*	4.54
Odds ratio	5.29	3.58	n/a
Less consumption of *Plectranthus edulis*			
Log-linear (χ^2)	2.92	0.47	0.87
Odds ratio	n/a	n/a	n/a

Not applicable as the association is not significant

Discussion

This study has analysed the effects of an intervention introducing improved potato varieties and cropping practices on the livelihoods of smallholder farmers. The effects of the intervention reported here are preliminary, as the period between the intervention (2013) and evaluation (2015) is short. Our findings show that, even after two years, diverse new potato production practices were emerging, patterned by wealth categories. Wealthy and medium-wealthy farmers applied more improved practices than poorer farmers. This is in line with earlier findings by Dersseh *et al.* (2016). Wealthy farmers who applied more improved cultivation practices generated more income from the surplus potato they produced, and this enabled them to acquire new assets. However, a few medium-wealthy and almost a third of the poor farmers had to sell off some assets in order to maintain the crop; purchasing seed potato and synthetic fertilizers for the next cropping season. This might be because these farmers lacked sufficient knowledge about the new potato technologies or they lacked the means to implement them. This emphasises that improved potato cropping practices require improved access to information, training and inputs if they are to be successful (Hirpa *et al.*, 2010; Limenih *et al.*, 2013).

There was a wealth based differentiation in the patterns of asset acquisition. Wealthy and medium-wealthy farmers acquired assets that required a relatively large amount of cash. Having a relatively small food gap enabled them to invest most of the cash from potato in long-term livelihood enhancement. Poor farmers invested in small businesses to diversify their income sources. This is in line with Tesfaye *et al.* (2013) who found that improved potato technologies had more impacts among adopters with better farm resources. These findings reflect that, while

agriculture remains a key driver of non-farm economic development, farming alone might not be a way to improve the livelihoods of poor farmers with very limited agricultural resources. Studies have also indicated that poorer farmers tend to participate in non-farm activities as alternative sources of income in order to reduce their vulnerability (Reardon, Delgado and Matlon, 1992; Akaakohol and Aye, 2014). Our findings also suggest that farmers in different wealth categories take different strategies to improve their livelihoods. In short, the livelihood effects of such an intervention cannot solely be attributed to technological change. Pre-existing differences in key farm resources also play a role. We found that these differences clearly influence farmers' uptake of new practices and their choice of how to invest any additional income. This implies the need to broaden the scope of interventions and to take into consideration the diversity of resources available to farmers, which in turn influences how rural households attempt to improve their livelihoods.

Improved potatoes are thought to have the potential for breaking cycles of hunger as they can be harvested before cereal crops have matured (Woldegiorgis *et al.*, 2015; Demo *et al.*, 2015). Our findings indicate that this potential was not fully realized. During food shortage periods, farmers adjusted their consumption patterns. There was no considerable change in the number of meals in a day, but after the intervention, they consumed more new potato varieties and maize than before. However, there was a mismatch between the time potatoes matured and the periods of food shortage. Farmers exhaust their home-produced supplies in the months of May, and October to Mid-November, whereas the improved potatoes matured from June to July and from December to January. Improved ware storage facilities, that could help farmers to stretch the availability of potato over a longer time period, were not part of the production practices of farmers who did not receive the construction material. Given the very low take up of this aspect of the package, more attention could perhaps be paid to encouraging farmers to construct better ware potato storage facilities as this could help bridge, or shorten the hungry gap.

There were indirect benefits of the intervention to farmers who did not receive the extension, although these benefits were mostly concentrated among the wealthier farmers. For example, the proportion of wealthy farmers who applied improved management practices and improved their livelihood situation was higher than the proportion of medium-wealthy and poor farmers. Wealthy farmers earned a higher proportion of their income from potato than poor farmers. The consumption of maize and potato was also more among wealthy farmers. These findings illustrate that improved potato technologies were not equally accessible to, or easy to implement

for, farmers in different wealth categories. Kassie *et al.* (2009) have noted that access to information and household endowments have a significant and positive impact on farmers' decisions to adopt, and benefit from, agricultural practices, such as conservation tillage, compost and chemical fertilizer.

Conclusions and implications

The introduction of new potato varieties and production practices has had a significant contribution in improving the livelihoods of farmers in the highlands of Chencha. However, these preliminary effects have not been uniformly distributed among farmers in different wealth categories. In general, the wealthy farmers who received improved seed potatoes and production technologies benefited more than other farmers. They generated better income, acquired more assets and improved their food consumption. Poorer farmers were less able to translate the technology into long-term livelihood improvements. This could be because they lack the complementary resources to benefit fully from the intervention. The results from this study show that the intervention enabled considerable adjustment in the type of crops consumed during food shortage seasons. Overall, the findings indicate that the types of change in farmers' livelihoods cannot be solely attributed to the technological intervention, but emerge from the interaction of the technology with farm realities that are grounded on the available farm resources, and a household's priorities. The main implication of this study is that while encouraging the adoption of new potato technologies may foster economic development, such technological interventions do not necessarily guarantee that farmers in different wealth categories will benefit equally. Farmers in different wealth categories adopted different strategies for improving their livelihoods. One should recognise the importance of these diverse strategies, especially those employed by poor farmers in order to build their productive resources and enhance their livelihoods. This could be done by integrating potato technology with other targeted farm and non-farm interventions. Finally, our results also imply the importance of the wider context and of disaggregating target groups in order to better understand and describe the, often very different, developmental effects of a single technological intervention.

References

Akaakohol, M. A., and Aye, G. C. (2014). Diversification and farm household welfare in Makurdi, Benue State, Nigeria. Development Studies Research 1 (1): 168–175.

Araya, A., Keesstra, S.D., and Stroosnijder, L. (2010). A new agro-climatic classification for crop suitability zoning in northern semi-arid Ethiopia. Agricultural and Forest Meteorology 150: 1057-1064.

Asefa, S. (2003). Rural poverty, food insecurity and environmental degradation in Ethiopia: A case study from south central Ethiopia. International Journal of Ethiopian Studies 1: 59-89.

Beyene, H. (2008). Adoption of improved teff and wheat production in crop livestock mixed system in northern and western Shewa zones of Ethiopia. Ph.D. Thesis University of Pretoria.

Bogale, A. (2012). Vulnerability of smallholder rural households to food insecurity in Eastern Ethiopia. Food Security 4: 581-591.

Cromme, N., Prakash, A.B., Lutaladio, N., and Ezeta, F.O. (Eds.) (2010). Strengthening potato value chains; technical and policy options for developing countries, pp. 1-147. FAO, Rome, CFC, Amsterdam, Rome.

Demo, P., Lemaga, B., Kakuhenzire, R., Schulz, S., Borus, D., Barker, I., Woldegiorgis, G., Parker, M.L., and Schulte-Geldermann, E. (2015). Strategies to improve seed potato quality and supply in sub-Saharan Africa: experience from interventions in five countries. In: Low J, Nyongesa M, Quinn S, and Parker M. (Eds.), Potato and Sweet Potato in Africa: Transforming the value chains for food and nutrition security, pp. 155-166, CAB International: London, UK.

Dersseh, W.M., Gebresilase, Y.T., Schulte, R., and Struik, P.C. (2016). The analysis of potato farming systems in Chencha, Ethiopia: Input, output and constraints. American Journal of Potato Research, 93: 436–447. doi:10.1007/s12230-016-9521-9

Field, A. 2009. Discovering statistics using SPSS (3rd ed.). London: Sage.

Food and Agriculture Organization of the United Nations (FAO) (2008) International Year of the Potato. Available at: http://www.potato 2008.org (accessed 02 June 2016).

Hirpa A., Meuwissen, M.P.M., Tesfaye, A., Lommen, W.J.M., Oude Lansink, A.G.J.M., Tsegaye A., and Struik, P.C. (2010). Analysis of seed potato systems in Ethiopia. American Journal of Potato Research 87: 537-552.

Kassie, M., Zikhali, P., Manjur, K., and Edwards, S. (2009). Adoption of sustainable agricultural practices: evidence from a semi-arid region of Ethiopia. Natural Resources Forum 33: 189-198.

Limenih, B., Tefera, T., and Lahiff, E. (2013). Determinants of adoption of improved potato varieties in Welmera Woreda. In: G. Woldegiorgis, S. Schulz, B. Berihun (Eds.), Seed Potato Tuber Production and Dissemination: Experiences, challenges and prospects, pp. 279-298, Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute.

Mazengia, W., Schulte, R., Tadese, Y., Griffin, D., Schulz, S., and Struik, P.C. (2015). The farming systems of potential potato production areas of Chencha, Southern Ethiopia, in: Low, J., Nyongesa, M., Quinn, S. & Parker, M. (Eds.), Potato and Sweet Potato in Africa: Transforming the value chains for food and nutrition security, pp. 382-395, CAB International: London, UK.

Negatu, W. (2008). Food security strategy and the productive safety net program in Ethiopia. In: Taye, A. (ed.). Digest of Ethiopian National Policies, Strategies and Programs, Addis Ababa. Forum for Social Studies (FSS): 1-22.

Reardon, T., Delgado, C., and Matlon, P. (1992). Determinants and effects of income diversification amongst farm households in Burkina Faso. Journal of Development Studies 28(2): 264–296.

Scott, G.J., Rosegrant, M.W., and Ringler, C. (2000). Global projections for root and tuber crops to the year 2020. Food Policy 25: 561-597.

Sen, D., Rakshit, A., Sarkar, N.C., Ghosh, D.C., and Bardhan Roy, S.K. (2010). Effect of transplanting dates and spacing on yield attributing character, productivity and economics of potato cultivation through true potato seed (TPS) technology. Italian Journal of Agronomy 5(1): 35-42.

Tesfaye, A., Woldegiorgis, G. and Kaguongo, W. (2013). Adoption and impact of potato production technologies in Oromiya and Amhara regions. In: Woldegiorgis, G., Schulz, S., and Berihun, B. (Eds.), Seed Potato Tuber Production and Dissemination: Experiences, challenges and prospects, pp. 256-278, Bahir Dar, Ethiopia: Ethiopian Institution of Agricultural Research, and Amhara Regional Agricultural Research Institute.

Winer, N. (1989). Agriculture and food security in Ethiopia. Disasters 13(1):1-8.

Woldegiorgis, G., Hailemariam, G., Lemaga, B. and Schulz, S. (2015). Quality seed potato production: Experiences from the Highlands of Ethiopia. In: Low J, Nyongesa M, Quinn S, and Parker M. (Eds.), Potato and Sweet Potato in Africa: Transforming the value chains for food and nutrition security, pp. 186-198, CAB International: London, UK.

CHAPTER 6

General discussion, synthesis and conclusions

Introduction

Smallholder farming is the dominant form of agricultural production in Africa (Krishna, 1977; Gollin, 2014). For decades, these farming systems have been subject to technology-oriented interventions – introducing improved varieties, improved soil fertility practices with use of synthetic fertilizers, improved cropping techniques, farm credit – with a view to improve food production (Borlaug and Dowswell, 1995; Aker, 2011). Interventions have been driven by governments, international donors and, in the last decennia, increasingly by NGOs, and have been aimed at a range of goals including poverty alleviation, closing of the yield gap and gender equality (Sumberg, Gilbert and Blackie, 2004). For some commodities, successes emerging in East, West, Southern and Central African agriculture show that new technologies have the ability to increase agricultural productivity of smallholder farmers, like in the case of the development and diffusion of high-yielding maize varieties, controlling mosaic virus and pests in cassava and expansion of export of vegetables and flowers (see Gabre-Madhin and Haggblade, 2004).

Despite such potential and emerging success stories, in many cases the use of those introduced agricultural technologies by smallholder farmers has remained below expectations (Wale and Yalew, 2007; Walker and Alwang, 2015, Meijer *et al.*, 2015). A broad range of explanations for this disappointing use of introduced technologies can be found in the literature (see for example, Feder, Just and Zilberman, 1985; Foster and Rosenzweig, 1995; Yila and Thapa, 2008). The studies on adoption or non-adoption of agricultural technologies can be grouped into three broad categories.

First, many studies have focused on the role of farm size, farmers' age and education status in determining the adoption (or rejection) of improved technologies. Adoption rates are relatively high among farmers who are young and relatively well educated, because they are willing to take up new information, which helps them to minimize the risk and uncertainty associated with new technologies. It has also been argued that farm size and/or location affect the adoption decisions (Feder, Just and Zilberman, 1985; Kebede, Gunjal and Coffm, 1990) because their owners would have more economic opportunities and be more open to change. Such findings do usually not assess the appropriateness of the technology *per se*: adoption is only evaluated in terms of successful uptake and non-adoption, and explained as a result of characteristics of the farm and farmer (Shaw, 1987).

The second group of studies relate to Rogers' diffusion theory, which describes how new technologies spread and are adopted over time (Rogers, 2003). This theory considers that the decision to adopt new technologies should be understood as a process that involves knowledge, persuasion, decision, implementation and confirmation. Following Rogers' diffusion theory, many studies attributed adoption decisions to the accessibility and availability of relevant information associated with a particular technology. Access to information in a timely manner through direct involvement in extension services is considered the main factor influencing the pace of adoption. The theory suggests that farmers with less access to information, therefore, will eventually adopt, once they become familiar with the technology. This is because information influences the knowledge about the new technologies and has the ability to persuade potential end users (Adesina and Zinnah, 1993; Argarwal, 1983; Röling, 1988; Anderson and Feder, 2007; Meijer *et al.*, 2015).

The third category of studies on adoption/non-adoption of technologies recognizes the importance of technology attributes in adoption decisions. Farmers assess the characteristics of new technologies against their objectives, constraints, strategies and expectations. Technologies that demand external inputs that are unaffordable to farmers, are less likely to be adopted. The mismatch between farmers' needs and characteristics of technologies negatively influences adoption decisions. Adoption or non-adoption of agricultural technologies is, therefore, associated with technologies that do or do not fit the context under which farmers operate (Chamber, Pacey, and Thrupp, 1989; Reece and Sumberg, 2003; Wale and Yalew, 2007).

The study described in this thesis addresses the complexity and social dynamics of technology-oriented interventions and adoption of improved potato production in smallholder farming, using Chencha, Southern Ethiopia, as the study area. Farmers' adoption of a new technology involves a dynamic process that follows the introduction of technology in which farmers either adopt or adapt parts of the new technologies, reject it, or use it differently than what was originally planned for. The adoption process is also shaped socially and farmers' practices are changing not only because of the technical changes introduced but also because of changes in their social circumstances. Despite the fact that adoption decisions involve such complex and dynamic processes, technology adoption is commonly understood as a binary choice between adopting and rejecting (Feder, Just and Zilberman, 1985; Pircher, Almekinders and Kamanga, 2013; Glover, Sumberg and Andersson, 2016). All these

observations indicate that decisions about new technologies are not limited to the characteristics of the farmers, their farms or technologies promoted, and that social context is important. The study shows how the social context contributes to farmers' adoption of the different technologies by socially disaggregating the adoption process, starting with the introduction of technologies up to tracing the impact on the livelihoods of farmers.

In this thesis, I analysed the influence of technology introduction strategies, social networks, differentiation and dynamics on the adoption, dissemination and effects of potato technologies represented by a combination of improved seed potatoes varieties, as well as agronomic field and storage practices. Potato is one of the strategic crops for ensuring household food security and income generation in Ethiopia, due to its high productivity potential, its short growing season and high energy content (Hirpa *et al.*, 2010; Woldegiorgis *et al.*, 2015). At the same time, there is a wide gap between the actual and attainable yields of potato (APHRD, 2009; Berihun and Woldegiorgis, 2013; CSA, 2014). Minimal access to quality seed of suitable varieties, poor crop management practices and potato diseases are the main factors for low potato productivity (Gildemacher *et al.*, 2009; Bekele *et al.*, 2013). These same constraints also challenge potato production and productivity in Chencha *wereda*, southern Ethiopia (Mesfin *et al.*, 2014). To improve the availability of quality seed and potato yield, and consequently income and food security of smallholders in Chencha, Vita, an international Irish-based NGO introduced potato technologies through different interventions for the last five years. To learn from these interventions, a research-based development programme was launched with the technical and financial support of Vita, Teagasc and Wageningen University. The research described in this thesis was part of this programme.

The ultimate objectives of this study were to improve the understanding of adoption (either wholly or partially), adaptation and rejection of the new varieties, cultivation and storage practices of potato and to generate useful insights for technology-oriented interventions that aim to support new potato production practices. In the next section of this chapter, the main results of the research reported in Chapters 2-5 are synthesized, linked to broader debates and discussed to address the main objective of the study and answer the specific research questions stated in Chapter 1 of this thesis. This Chapter 6 also reflects upon the conclusions and implications of the findings for technology-oriented interventions.

Social differentiation, social networks and technology diffusion

The interventions that introduced the improved potato production technologies - a combination of improved varieties, improved quality of seed potatoes, and improved agronomic field and storage practices - in Chencha, southern Ethiopia, had mixed results. Social differentiation and social networks were linked with diffusion of potato technologies. Wealthy and medium-wealthy farmers had first-hand access to good quality seed potatoes of new varieties and to improved production and storage technologies (Chapters 2, 3 and 4). This was mainly because the interventions implemented in this locality in the specific years were based on the "progressive farmer strategy". This strategy is built on the assumption that once the progressive farmers - farmers who are quicker to follow the advices from extension practitioners and belong to a socio-economically advantaged sub-group (Röling *et al.*, 1976; Röling, 1988) - shift to the new production practices, the practice will be copied by less progressive farmers. Progressive farmers 'presumably' pass on the lessons to other farmers (Röling *et al.*, 1976; FAO and UNDP, 2001; Cohen and Mamusha, 2011). Although it is usually not made explicit how this takes place, it assumes the existence of social interaction and some sort of a social network. The analysis of farmer-to-farmer seed sharing practices showed that seed is shared through a network of social relations. In the seed sharing network new potato varieties flowed from wealthy to medium-wealthy and poor farmers. After two years, the proportion of the total number of poor farmers who had accessed the seed increased to 40%; none of the poor farmers had received seed tubers directly from the intervention. The main factor motivating seed providers to share seed with other farmers was in exchange for labour support in various cropping activities. In some cases, seed providers wanted to keep up the social relationship they had with seed recipients. It indicates the interdependency of farmers belonging to different wealth groups, which may represent social safety nets for poor farmers who are seed and food insecure. It also indicates the crucial role of farmer seed networks for the diffusion of planting materials. More than half of the poor farmers who accessed seed from other farmers were also not able to save seed for the next planting season from their own harvest. Potato diseases and lack of agronomic knowledge were the reasons for low yields, which further limited the ability to save seed and thereby possible seed dissemination from poor farmers to other farmers.

Thus, the access to seed of improved varieties was influenced by the socio-economic characteristics of and relations between the farmers in the communities. While seed was

handed down from wealthier farmers to their neighbours, friends and poorer farmers who provided them with services (e.g. field labour and 'running errands') our research also indicated that quite a number of farmers might not be bounded into the social network of those wealthier farmers who directly obtained improved seed from the NGO. These farmers just simply did not show up in our data when we traced the seed sharing. It does not mean that farmers who might not be part of a farmer seed network could not acquire seed through other sources. The findings in Chapter 2, for instance, indicated that the local market was one of the main sources of improved seed potatoes among the majority of medium-wealthy and poor farmers. Markets are, therefore, one of the important optional seed sources among farmers, as also found in the studies by CRS and Partners (2006), Sperling and McGuire (2010) and McGuire and Sperling (2016). Our findings thereby confirm the fact that not all farmers have equal access to new potato varieties as has been earlier reported by Cromwell and Tripp (1994) and McGuire (2007), but that nevertheless the introduction of new varieties through wealthier farmers was relatively effective as they are sharing most frequently with other farmers.

This study found that new potato cultivation practices that accompanied the use of new varieties, such as proper rotations, planting in ridges or improved post-harvest handling often failed to spread to poor farmers (Chapters 2 and 5). Poor farmers planted potato in flat soil rather than in ridges, and medium-wealthy and poor farmers did not use the recommended crop rotation to combat bacterial wilt. Access to knowledge on these practices was an important factor in explaining variation in adoption of improved production practices across wealth categories, which has to do partly with the intervention of the NGO that targeted progressive farmers. Feder and Slade (1984) also suggested that farmers with better level of information about the new technologies will adopt earlier than other farmers. Notwithstanding this, at least a part of the farmers who were not directly part of the NGO intervention or supported by extension services had alternative means of accessing information about the new technologies, as was shown in our surveys with at random sampled farmers and in which used practices and impact were explored (Chapters 2 and 5): they were however mostly wealthier and medium-wealthy farmers.

Social differentiation, technology compatibility and effects

Next to not having equal access to the technology, i.e. the improved seeds, and/or information, not all farmers have the same technology needs and preferences. The context in

which farmers produce improved potato varieties varies from farmer to farmer. Within these different contexts, the availability of labour, land, and cash were the major determinants for farmer potato production practices (Chapter 2). For some of the wealthy and medium-wealthy farmers, for example, shortage of labour was a reason for not tilling as frequently as recommended, or for not planting in ridges. The size of tubers to be planted and amount of fertilizers to be applied deviated from recommended practices partly due to cash shortages. When farmers are aware of and have access to the existing production technologies, the assumption is they are likely to take up and reap the benefits of these technologies. My findings show, however, that not all farmers who have access to technologies make them part of their practices: the variation in needs and constraints of the farmers belonging to different wealth categories determines the attractiveness of the improved technology, and thus adoption. Giller *et al.* (2009) also found that farm resources influence adoption decision because adopting new technology requires not only what should be done on one field, but involves trade-offs with other activities from which the farmers generated their livelihoods. The heterogeneity of smallholder farmers in terms of resources, concerns and expectations needs to be recognized for agricultural technology to be successfully taken up (Wale and Yalew, 2007). In the case of the improved potato technologies in Chencha this finding means that a single technology package with blanket recommendations could not fit to the diversity of circumstances of smallholder farmers belonging to different socio-economic groups.

The variation in technology adoption also resulted in diverse effects on the livelihood of smallholders across wealth categories (Chapter 5). Wealthy participant farmers had more changes in agronomic practices, earned more income and invested it mainly in assets that required relatively large amounts of cash such as house construction and livestock while the investment among poor farmers was either on household equipment or small businesses: selling (and buying) cereals, weaving products and milk products in the local markets that enabled them to generate cash quickly. This indicates that while poor farmers prioritized gaining more income, wealthy farmers ploughed back some portion of the income from potato into productivity of the farms through purchasing livestock. The introduction of new potato technologies also had effects on the potato production practices and economy of farmers who had not been direct beneficiaries of the NGO project intervention. The proportion of wealthy non-participant farmers who experienced changes in their potato management practices and economy, however, was higher than of poor non-participant farmers. The consumption of maize and potato was, therefore, higher among wealthy farmers. The finding indicates that

farmers' benefit from agricultural technology is conditional on the pre-existing farm resources and households' priorities.

Collective action and technology

In the foregoing, I discussed the experiences related to the diffusion and adoption of improved practices and seed in potato production and showed how these are influenced by social differentiation at the level of community and in a social network. In this study, another aspect of social dynamics became important when I studied the experiences of two potato seed cooperatives. These experiences of the two farmer groups on collectively producing and marketing quality seed potato, presented in Chapter 4 showed how collective action, regulated in the form of rules of the cooperatives, can be in tension with maintaining quality in the multiplication of potato seed. In the first two years, members (wealthy and medium-wealthy) of the two young potato cooperatives were actively producing and marketing potato planting material at the community level. Members of seed cooperatives supplied on average 1.9-2.7 tonnes of seed potatoes to institutional buyers, NGOs and nearby *wereda* Agricultural Offices. Seed inspection committees composed of a chairperson and two members were assessing and assuring the quality of seed supplied through cooperatives, even if they did not use specific criteria for accepting or rejecting a seed plot. As pointed out by Bijman (2016), the external support to the farmer organization proved important: the provision of improved seed, construction materials for building improved seed storages and training in agronomic and storage practices by extension professionals, and the organisation of pooled labour for agronomic activities by the NGO staff all contributed to collective seed potato production and marketing.

The analysis of the farmer cooperative groups also showed the tensions between prescriptive rules, solidarity and individual interests. The formation of cooperatives was guided by the usual approach of organizing farmer groups under rules determining how cooperatives should be organized and managed. The intervention also focused more on improving members' seed potato production capacity and less on building good governance of the seed chain. For example, members who experienced seed lot rejection by inspecting committees were not happy with the decision because they were not compensated for what they lost. Compensation was not part of the by-law as the cooperatives had very limited financial resources. In addition to this, there were instances where inspection committees accepted seeds that came from rejected seed lots: they did not want to lose the positive relationship they had with the rest of

the members, as they were part of the same community. Overall, cooperative leaders found it very hard to maintain quality seed standards and friendship at the same time. This raises questions about the potential of internal seed quality control as is now proposed in many decentralised and community seed production initiatives.

Members' satisfaction and active participation, and effective communication between members and management are essential for the success of farmer-owned cooperative organizations (Bhuyan, 2007; Wadsworth, 2001). In the studied seed cooperatives, the main mechanisms for building transparent and accountable communication within cooperatives were not optimally utilized. Meetings among committee members and annual meetings among all members, for instance, were not held on a regular basis. These meetings were missed opportunities for responding to members' needs and satisfaction. Some of the members did also not get the full price for the seed they supplied to the cooperative and their claim for the remaining money was ignored by the cooperative executive committee, thereby undermining one of the most important incentives for cooperation in producer organization, i.e. the economic gains (Shiferaw *et al.*, 2016). It also leads to mistrust of cooperative leaders and reduced interest in cooperation for quality seed potato production and marketing.

The root of having weak seed cooperatives may not be a lack of intent towards building durable farmer-groups. Rather, development practitioners did not take the set-up of strong farmer-groups as an evolving process, which continually engages in diagnosis and responding to the emerging social as well as material challenges. They also did not acknowledge the tensions between collective action and individual interest and community level social differentiation, the poor not being part of the cooperatives. For instance, farmers developed some technical know-how about quality seed production. They are eager to obtain the benefits from producing quality seed: diversifying means of income, asset acquisition and minimizing food shortage. Obtaining such benefits demands not only individual efforts but also incrementally developed skills and know-how on good governance among cooperative leaders. It also demands legislative enforcing context: without the possibilities to actually enforce rules and regulation a member might revert to the practices that fit his/her particular interests and realities (e.g., doing cropping practices that do not enable to keep up the quality of seed and selling seed in local market).

Conclusions: implications for technology-oriented interventions

This study shows that social differentiation among farmers plays an important role in understanding technology adoption and diffusion. Wealthy farmers have first-hand access to potato technologies introduced in the locality; these improved potato production practices also fit well with their farm reality, because they have farm resources and can afford external inputs required to make the new technologies practical. Wealthy model farmers are thus easier to work with and get results quickly when introducing improved production practices that require more inputs. Moreover, wealthy farmers had an important role in the multiplication and dispersion of new potato varieties in farmer seed networks and through seed cooperatives. From a practitioners' point of view, therefore, targeting potato technological interventions towards wealthy farmers could be considered effective, with the assumption that improved potato production technologies will, over time, 'trickle down' to all producers, once leading farmers accessed and adopted it. The findings reported in this thesis highlight that, from a seed multiplication and dissemination point of view, interventions targeting wealthy farmers were relatively effective as planting materials have diffused to all categories of the community. However, from potato production and management point of view, the intervention could have had better results because the cropping practices associated with improved seed potatoes did not disseminate to other farmers as expected. Thus, many of the "shared" seed potatoes were not planted for more than one planting season. The experience of seed potato cooperatives also showed that collective production and marketing could not solve crop management problems, which makes it hard to form independent and successful farmer organizations. Moreover, the resulting positive effects of potato technologies at household level show that the intervention has benefits mainly for wealthier farmers. All this raises concerns about the equitability and effectiveness of technology-oriented interventions.

Findings in this thesis have important implications for technology-oriented interventions:

i. In order to ensure that technology interventions result in improved livelihoods through all socio-economic groups, the targeting strategy of interventions should be inclusive of members of all categories.

ii. To maximize the adoption of new cropping practices, the interventions should offer a range of technology options and associated information on the costs and optimal

benefits of technology options that fit with the farm context of farmers belonging in different socio-economic groups.

iii. The set-up of farmer-group based seed production demands resources and faces contextual challenges which could not be easily addressed by farmers alone. This calls for interventions focused on building farmer groups. These interventions, however, need to shift from 'standard production models' to an evolving model: an open and flexible model guided by trials, challenges and existing socio-technical and institutional realities. When farmer organizations develop gradually through addressing the contextual challenges and meeting the needs of their members they become strong, independent and successful. To do so, cooperative members and leaders need an opportunity for learning by doing, which helps to make a balance between the external support and self-reliance.

iv. Farmers in different wealth categories took different strategies for their livelihood improvement using the income from potato: farm and non-farm activities, which indicates that interventions introducing technologies alone might not necessarily be an effective way for livelihood improvement in equal manner among farmers in different wealth categories. This implies that there is a need for considering agriculture as part of a wider set of rural development processes that include enterprise development and off-farm employment; and capacity development in terms of strengthening institutional development to improve the socio-economic position of farmers. Specifically, there is a need for integrated and targeted farm and off-farm interventions that take into consideration the different livelihood strategies of farmers across wealth groups. This helps to broaden the focus of interventions beyond introducing technologies.

References

Adesina, A.A. and Zinnah, M.M. (1993). Technology characteristics, farmers' perceptions and adoption decisions: A Tobit model application in Sierra Leone. Agricultural Economics, 9: 297-311.

Anderson, J.R. and Feder, G. (2007). Agricultural extension. In: R. Evenson and P. Pingali (Eds.), Agricultural development: farmers, farm production and farm markets. Handbook of agricultural economics. Amsterdam: Elsevier, 3: 2343–2378.

Aker, J.C. (2011). Dial "A" for agriculture: a review of information and communication technologies for agricultural extension in developing countries. Agricultural Economics, 42: 631–647.

APHRD (Animal and Plant Health Regulatory Directorate). (2009). Crop Variety Register, Issue No. 12, June, 2009. Ministry of Agriculture and Rural Development, Addis Ababa, Ethiopia.

Argarwal, B. (1983). Diffusion of rural innovations: some analytical issues and the case of wood burning stoves. World Development, 11(4): 359-376.

Bekele, B., Abate, E. and Asefa, A. (2013). Viruses and bacterial wilt disease of potato in western Amhara. In: G. Woldegiorgis, S. Schulz and B. Berihun (Eds.), Seed potato tuber production and dissemination: experiences, challenges and prospects, proceedings of the national workshop on seed potato tuber production and dissemination, 12-14 March 2012, Bahir Dar, Ethiopia, pp. 241-255.

Bhuyan, S. (2007). The "people" factor in cooperatives: an analysis of members' attitudes and behaviour. Canadian Journal Agricultural Economics, 55: 275-298.

Bijman, J. (2016). The changing nature of farmer collective action: introduction to the book. In: J. Bijman, R. Muradian and J. Schuurman (Eds.), Cooperatives, economic democratization and rural development, Edward Elgar Publishers: UK and USA, pp. 1-24.

Borlaug, N.E. and Dowswell, C.R. (1995). Mobilising science and technology to get agriculture moving in Africa. Development Policy Review, 13: 115-129.

Chambers, R., Pacey, A.P. and Thrupp, L.R. (1989). Farmer first: farmer innovation and agricultural research. London: IT technology publication.

Cohen, M. J. and Mamusha, L. (2011). Agricultural extension services and gender equality. An institutional analysis of four districts in Ethiopia. IFPRI Discussion Paper.

Cromwell, E. and Tripp, R. (1994). Proximity is a plus: the economics of farmer seed production and distribution in developing countries. Proceedings of the ILCA/ICARDA

workshop on Seed Production by Smallholder Farmers. Addis Abeba. 13-15 June 1994. Addis Abeba: ILCA, pp. 15-23.

CRS (Catholic Relief Services) and Partners. (2006). Seed system security assessment (SSSA) Douentza, northern Mali. Bamako: CRS/Mali. Final Report.

CSA (Central Statistical Agency). (2014). Agricultural sample survey report on area and production (Private peasant holdings in Meher season). Addis Ababa: Statistical Bulletin.

FAO and UNDP (2001). Client-oriented extension training: Ethiopia. In: Sharing innovative experiences: examples of successful initiatives in agriculture and rural development in the South, FAO, Rome, volume 5, 279-293.

Foster, A.D. and Rosenzweig, M.K. (1995). Learning by doing and learning from others: human capital and technical change in agriculture. The Journal of Political Economy, 103(6): 1176-1209.

Feder, G. and Slade, R. (1984). The acquisition of information and the adoption of new technology. American Journal of Agricultural Economics, 66(3): 312-20.

Feder, G., Just R. and Zilberman D. (1985). Adoption of agricultural innovations in developing countries: a survey. Economic Development and Cultural Change, 33: 255–297.

Gabre-Mahdin, E. and Haggblade, S. (2004). Successes in African agriculture: results of an expert survey. World Development, 32(5): 745–766.

Gildemacher, P.R., Kaguongo, W., Ortiz, O., Tesfaye, A., Woldegiorgis, G., Wagoire, W.W, Kakuhenzire, R., Kinyae, P.M., Nyongesa, M., Struik, P.C. and Leewis, C. (2009). Improving potato production in Kenya, Uganda and Ethiopia: A system diagnosis. Potato Research, 52: 173–205.

Giller, K.E., Witter, E., Corbeels, M. and Tittonell, P. (2009). Conservation agriculture and smallholder farming in Africa: The heretics view. Field Crop Research 114: 23-34.

Glover, D., Sumberg, J. and Andersson, J.A. (2016). The adoption problem; or why we still understand so little about technological change in African agriculture. Outlook on Agriculture, 45(1): 3-6.

Gollin, D. (2014). Smallholder agriculture in Africa: an overview and implications for policy. IIED Working Paper. IIED, London.

Hirpa A., Meuwissen, M.P.M., Tesfaye, A., Lommen, W.J.M., Oude Lansink, A.G.J.M., Tsegaye A. and Struik, P.C. (2010). Analysis of seed potato systems in Ethiopia. American Journal of Potato Research, 87: 537-552.

Kebede ,Y., Gunjal, K., and Coffin, G. (1990). Adoption of new technologies in Ethiopian agriculture: The case of Tegulet-Bulga district, Shoa province. Agricultural Economics, 4: 27-43.

Krishna, K.G.V. (1977). Smallholder agriculture in Africa constraints and potential. American Academy of Political and Social Science, 432(1): 12-25.

McGuire, S.J. (2007). Vulnerability in farmer seed systems: farmer practices for coping with seed insecurity for sorghum in Eastern Ethiopia. Economic Botany, 61(3): 211–222.

McGuire, S. and Sperling, L. (2016). Seed systems smallholder farmers use. Food Security, 8: 179–195.

Meijer, S.S., Catacutan, D., Ajayi, O.C., Sileshi, G.W. and Nieuwenhuis, M. (2015). The role of knowledge, attitudes and perceptions in the uptake of agricultural and agroforestry innovations among smallholder farmers in sub-Saharan Africa. International Journal of Agricultural Sustainability, 13(1): 40-54.

Mesfin M., Girmay, G. and Woldeyes, F. (2014). Enhancing household food security through Irish potato production in Gamo Highlands of Southern Ethiopia, Scholarly Journal of Agricultural Science, 4(7): 410-419.

Pircher, T., Almekinders, C.J.M. and Kamanga, B.C.G. (2013). Participatory trials and farmers' social realities: understanding the adoption of legume technologies in a Malawian farmer community. International Journal of Agricultural Sustainability, 11(3): 252-263.

Rees, D., Momanyi, M., Wekundah, J., Ndungu, F., Odondi, J., Oyure, A. O., Andima, D. Kamau, M., Ndubi, J., Musembi, F., Mwaura, L. and Joldersma, R. (2000). Agricultural knowledge and information systems in kenya – implications for technology dissemination and development. Agricultural Research and Extension Network, Network Paper No.107.

Reece, D. and Sumberg, J. (2003) More clients, less resources: toward a conceptual framework for agricultural research in marginal areas. Technovation, 23: 409–421.

Röling, N.G., Ascroft, J. and Chege, F.W. (1976). The diffusion of innovations and the issue of equity in rural development. Communication Research, 3(2): 155-170.

Röling, N. (1988). Extension science: information system in agricultural development. Cambridge University Press.

Rogers, E.M. (2003). Diffusion of innovations (5th ed.). New York: Free Press.

Shaw, A.B. (1987). Approaches to agricultural technology adoption and consequences of adoption in the third world: A critical review. Geoforum, 18(1): 1-19.

Shiferaw, B., Hellin, J. and Muricho, G. (2016). Markets access and agricultural productivity growth in developing countries: challenges and opportunities for producer organizations. In: J. Bijman, R. Muradian and J. Schuurman (Eds.), Cooperatives, economic democratization and rural development. Edward Elgar Publishers: UK and USA, pp. 103-122.

Sperling, L., and McGuire, S. (2010). Understanding and strengthening informal seed markets. Experimental Agriculture, 46(2): 119–136.

Wadsworth, J. (2001). Keep the co-op candle burning. Rural Cooperatives, 68(2): 19-20.

Wale, E,. and Yalew, A. (2007). Farmers' variety attribute preferences: Implications for breeding priority setting and agricultural extension policy in Ethiopia. Journal Compilation African Development Bank, 379-396.

Walker, S.T., and Alwang, J. (2015). The importance of generating and documenting varietal change in sub-Sharan Africa. In: S.T. Walker and J. Alwang (Eds.), Crop improvement, adoption and impact of improved varieties in food crops in sub-Sharan Africa. CGIAR and CAB International, UK and USA, pp. 1-6.

Woldegiorgis, G., Hailemariam, G., Lemaga, B. and Schulz, S. (2015). Quality Seed Potato Production: Experiences From the Highlands of Ethiopia. In: J. Low, M. Nyongesa, S. Quinn and M. Parker (Eds.), Potato and sweet potato in Africa: Transforming the value chains for food and nutrition security. CAB International: London, UK, pp. 186-198.

Yila, O.M. and Thapa, G.B. (2008). Adoption of agricultural land management technologies by smallholder farmers in the Jos Plateau, Nigeria. International. Journal of Agricultural Sustainability, 6(4): 277-288.

Summary

Interventions are introductions of technologies (tools and practices) to improve crop productivity. Although these technologies are postulated to improve food production in sub-Saharan Africa, their uptake is low and diverse among smallholder farmers: certain farmers adopt new technologies (either wholly or partially), while others adapt or even reject them. Literature provides various explanations for the poor adoption and diversity in adoption decisions. Insights are missing, however, on how social dynamics influence the adoption decisions of smallholders. This thesis, therefore, analyses the influence of technology introduction strategies, social networks and social differentiation on the adoption, dissemination and effects of potato technologies. Interventions promoting improved potato technologies in Chencha, Southern Ethiopia, was the focus of the study, with the overall objective of contributing to a better understanding of constraints affecting technology adoption and suggesting possible ways of improving the effect of technology-oriented interventions for intended beneficiaries.

The introduction in Chapter 1 provides an overview of technology interventions for smallholder farmers in sub-Saharan Africa and the challenges of technologies introduced to improve food production for smallholder farmers. It also describes the general research objectives, research design of the thesis, the role of non-governmental organization in agricultural extension and challenges for improving potato production and productivity in Ethiopia.

Chapter 2 examines the context in which farmers produce potato and how this context influences crop management practices of smallholder farmers. In particular, it analyses how wealth status affected the adoption of improved potato varieties and explains the variation among farmers in applying improved potato production practices. Data were collected through a survey and in-depth interviews. The results show that farmers face diverse constraints to the adoption of improved potato production practices, mainly determined by the availability or absence of knowledge, labour, land, and cash. Most wealthy and some medium-wealthy farmers adopted many of the introduced practices because they had first-hand access to seed, support for the construction of diffuse light stores and knowledge from the development agencies. Most poor farmers, however, could not explain the improved practices such as planting in ridges, improved storage practices and crop rotation as they were

not well aware of the new practices. Adoption of potato production practices was further limited by cash and labour constraints. Some of the wealthy and medium-wealthy farmers could not till as frequently as recommended, could not to plant in ridges or could not harvest at once due to labour shortage. In addition, the constraint in cash influenced farmers' decision on which seed tuber size to plant, to construct a DLS, and to invest in the application of synthetic fertilizers. This implies that for wealthy farmers improved potato technology is relevant for at least part of their potato plots, but for poor farmers the improved technology is not an option because it does not fit their socio-economic conditions: they are too poor and their farms are too small. Thus, there is a need to offer farmers a range of technology options and room to experiment and assess outcomes. This needs to be accompanied with access to the knowledge and inputs to successfully adopt the new production practices.

Few studies have empirically addressed the flow of seed from farmer-to-farmer to assess the effect of social barriers on the diffusion of new varieties. **Chapter 3** looked into this less documented aspect of farmer seed network. Specifically, we unravelled how social differences defined by wealth, gender and religion influenced the farmer-to-farmer diffusion of recently introduced new potato varieties. Tracing the seed and the analysis of seed sharing characteristics showed that there is no equal access to seed of new potato varieties. The seed trickled down from higher wealth categories to the lowest. Wealthier farmers shared seed with a larger number of poor and medium-wealthy farmers than wealthy farmers. This suggests a strong interdependence amongst different wealth groups which may strengthen social safety nets and informal 'insurance' institutions. Poor farmers did not share seed with other farmers because the amount of seed they accessed and planted was small and crop loss was common due to potato diseases and lack of agronomic knowledge. Men shared more with men, and women more with women. Seed sharing with acquaintances facilitated sharing across gender while family ties were an important mechanism for seed sharing between wealth categories, genders and religions. Hence, failing to understand the dynamics of social differentiation within the community would make it difficult to know what targeting strategy would work and which would work best.

There are many initiatives to set up farmer-group based seed production and internal seed quality control mechanisms in order to improve the availability of clean seed. However, there is less empirical evidence about the group functioning in producing and marketing quality seed. **Chapter 4**, therefore, captured how farmer groups produce, maintain and market quality

seed potato. In the first two years, the farmer groups improved the availability of clean seed potatoes at the community level and group members economically benefited from the new potato technologies accompanied by the training on agronomic practices. The production of clean seed and economic benefit, however, could not be sustainable because (i) the meetings among committee members and annual meetings among all members, which were the main mechanisms for building transparent and accountable communication within farmer groups, were not properly utilized, (ii) the intervention focused more on improving members' seed potato production capacity and less on building good governance of the seed chain, (iii) the bylaws had no provisions for issues associated with seed production and seed quality maintenance. For example, what to do when members face seed loss and seed inspection becomes beyond the capacity of the quality controlling committee, and (iv) decisions on seed quality had a negative implication on the social relationships of cooperative and committee members. This chapter underlines seed quality management goes beyond following technical prescriptions and demands a long-term approach, which continually engages in diagnosis of what the relevant material and social problems are, and responding to changes and new challenges occurring.

In **Chapter 5** we explored the role of improved potato technologies in improving the livelihood of smallholder farmers. The study found that, compared with poor farmers, wealthy farmers who did and did not receive extension applied more improved production practices. This enabled the wealthy farmers to earn more income, acquire new assets and improve food consumption while poorer farmers were less able to translate the technology into long-term livelihood improvements. The asset acquisition was not uniform among farmers in different wealth categories. Wealthy farmers acquired assets that required a relatively large amount of cash. Poor farmers, however, invested in small businesses to diversify their income sources. The potential of potatoes for breaking cycles of hunger was also not fully realized. This was because of the mismatch between the time potatoes matured and the periods of food shortage and the low uptake of improved ware storage facilities that could help bridge, or shorten, the hunger period. This indicated that the interventions do not necessarily provide equal benefits for farmers in different wealth categories because the technologies were not equally accessible or easy to implement. There is a need for interventions that take into account the diversity of farm resources and farmers' livelihood strategies across wealth categories.

Finally, the general discussion chapter (**Chapter 6**) pulled together the main results of the research, linked the key results to the broader debates and suggested possible options to enhance the likelihood that technology-oriented interventions improve potato production among smallholder farming. The results in this study provided better understanding of social differentiation, social networks and social pressure as opportunities and constraints for the adoption-diffusion process at one hand and diversity of needs for technology and effects of technology at the other hand. In addition, the final chapter discussed how social relationship is a challenge for farmer-group based seed production, as the process of clean seed potato production and dissemination become part of farmers' day-to-day life.

Biography

Yenenesh Tadesse, born in Addis Ababa in 1977, obtained a degree in Sociology and Social Administration in 2003 from Addis Ababa University (A.A.U), Ethiopia. After graduation, she worked successively as Gender Study and Policy Performance Follow-up Expert in the Ministry of Water Resources and as Urban Development Project Officer in Vita Ethiopia. After four years, she attended the Master of Social Work programme and graduated from A.A.U. in 2009. Her master thesis dealt with the experience of obstetric fistula survivors: the case of women for women foundation.

After her master study, she worked as Program Gender, Liaison and Reporting Officer in Vita Ethiopia. She took a leading role in developing the gender policy of the organization. She also developed and implemented training seminars on women and gender issues. Then, as a Program Planning, Monitoring and Evaluation Officer, she was responsible for establishing an effective and participatory monitoring and evaluation system; promoting and monitoring the implementation of gender mainstreaming; and conducting research into areas of special interest of the organization – agriculture, sanitation, climate change, sustainable livelihoods, mainstreaming.

To learn more about interventions introducing agricultural technologies, she joined Wageningen University at the beginning of 2012. She conducted this PhD research on interventions introducing potato technologies in Southern Ethiopia under the supervision of the Centre for Crop Systems Analysis and the Knowledge, Technology and Innovation group. Her PhD assessed the influence of technology introduction strategies, social networks and social differentiation on the adoption, dissemination and effects of potato technologies.

Contact: yeneneshtadesse@gmail.com

Publication list

Journal papers, book chapter and research news letter

Tadesse, Y., C.J.M. Almekinders, R.P.O. Schulte, and P.C. Struik (2017). Understanding farmers' potato production practices and use of improved varieties in Chencha, Ethiopia. Journal of Crop Improvement. DOI: 10.1080/15427528.2017.1345817.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2016). Tracing the seed: seed diffusion of improved potato varieties through farmers' networks in Chencha, Ethiopia. Experimental Agriculture. DOI 10.1017/S001447971600051X.

Dersseh, W.M., **Gebresilase, Y. T.**, Schulte, R.P.O. and Struik, P.C. (2016). The analysis of potato farming systems in Chencha, Ethiopia: input, output and constraints. American Journal of Potato Research, 93: 436-447. DOI 10.1007/s12230-016-9521-9.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2015). Putting technology into practice: understanding the adoption of best practices. TResearch-Winter, 10(4): 12-13.

Mazengia, W., Schulte, R., **Tadesse, Y**., Griffin, D., Schulz, S. and Struik, P.C. (2015). The farming systems of potential potato production areas of Chencha, Southern Ethiopia, in: Low, J., Nyongesa, M., Quinn, S. and Parker, M. (Eds.). Potato and Sweet Potato in Africa: transforming the value chains for food and nutrition security, pp. 382-395, CAB International: London, UK.

Tadesse, Y. (2014). A qualitative study of the experience of obstetric fistula survivors in Addis Ababa, Ethiopia. International Journal of Women's Health, 6: 1–11.

Tadesse, Y. (2010). Community led total sanitation and empowerment: the case of Dorze Hyzo community, SNNP region of Ethiopia, Ontario International Development Agency, OIDA International Journal of Sustainable Development, 01(09): 99-107.

Conferences

Struik, P., Abdulrahman, A., Dersseh, W., **Gebresilase Y**., Griffin, D., Weakliam, J., Woldegiorgis, G., Schultz, S., Almekinders, C. and Schulte, R. (2017). Improving potato cultivation in Ethiopia. abstract presentation at 20th EAPR Triennial Conference, July 9-14, 2017, Versailles, France.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2016). Why do farmers adopt, adapt or reject new potato production practices? Insights from Chencha, Ethiopia. Poster presentation in sustainable agriculture and economic growth:

smallholder farmers between markets, policies and environmental change workshop, 5-8, June 2016), Bonn, Germany.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2016). Why do farmers' potato production practices differ? insights from Chencha, Ethiopia. Poster presentation in contested agronomy: whose agronomy counts? conference, 23-25, February 2016, Brighton, England.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2015). Farmers' potato production and seed sharing practices in Chencha, Ethiopia. Oral presentation in Research and Knowledge Transfer for Global Food Security Seminar, 12th, June 2015, Dublin, Ireland.

Struik, P., Abdulrahman, A., Dersseh, W., **Gebresilase Y**., Griffin, D., Weakliam, J., Woldegiorgis, G., Schultz, S., Almekinders, C. and Schulte, R. (2014). Improving seed-to-ware, ware and knowledge chains in potato cultivation in Eastern Africa. Abstracts EAPR 2014, Brussels, 2014, no. 13.

Tadesse, Y., Almekinders, C.J.M., Schulte, R.P.O. and Struik, P.C. (2013). Farmers' Potato Production Practices, Chencha, Ethiopia. Poster presentation at 9th Triennial African Potato Association Conference, 30th June - 4th July 2013, Naivasha, Kenya.

PE&RC Training and Education Statement

With the training and education activities listed below the PhD candidate has complied with the requirements set by the C.T. de Wit Graduate School for Production Ecology and Resource Conservation (PE&RC) which comprises of a minimum total of 32 ECTS (= 22 weeks of activities)

Descriptions	Department/Institute	Year	*ECTS
I. Project Related Competence			
Practical training and exercise on social media and knowledge transfer methods on BETTER farm programme	Teagasc; Carlow, Ireland	2012	4.5
Introduction to technology, agroecology and development	CPT-CID, WUR	2014	4
Linear models	PE&RC, WUR	2012	0.9
II. Research Methods and Techniques			
Writing of project proposal	CSA and KTI, WUR	2012	4.5
Review of literature: the promotion, adoption and impact of potato technologies in Ethiopia	CSA and KTI, WUR	2015	6
Techniques for writing and presenting a scientific paper	WGS, WUR	2012	1.2
Information literacy including EndNote introduction (ILP)	WGS, WUR	2012	0.6
Reviewing journal manuscripts (RCP)	WGS, WUR	2015	0.1
III. Seminars, Meetings and Workshops Presentations and Attendance			
Centre for Crop System Analysis (CSA) lunch seminars	CSA, WUR	2012	1
PE&RC Introduction weekend	PE&RC, WUR	2012	0.9
9th Triennial African Potato Association conference	Naivasha, Kenya	2013	2.5
Scientific meetings on PhD project progress in Wageningen, Ireland and Ethiopia	Teagasc, WUR and Vita	2012, 2014, 2015	1.5
Knowledge, Technology and Innovation (KTI)	KTI, WUR	2014, 2015, 2016	1.5
Science for impact: focus on enabling conditions (2015)	PE&RC, WUR	2015	0.3
PE&RC Last year weekend	PE&RC, WUR	2015	0.6
Farmers' workshop; oral presentation; Chencha Woreda, Ethiopia	Teagasc, WUR and Vita	2015	1.5
Stakeholder seminar; oral presentation; Addis Ababa, Ethiopia	Teagasc, WUR and Vita	2015	1
Social science discussion group	KTI, WUR	2015, 2016	1
Research and Knowledge Transfer for Global Food Security seminar	Dublin, Ireland	2015	1.3
Contested agronomy: whose agronomy counts? conference	Brighton, United Kingdom	2016	1.9
Sustainable agriculture and economic growth: smallholder farmers between markets, policies and environmental change workshop	Bonn, Germany	2016	2.2
Total			**39**

*One credit according to ECTS is on average equivalent to 28 hours of study load

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