The Defining Moments in Ethiopian Seed System

Edited by

Adfris T/Wold
Asnake Fikre
Dawit Alemu
Lemma Desalegn
Abebe Kirub

የኢትዮጵያ የግብርና ምርምር ኢንስቲትዩት
Ethiopian Institute of Agricultural Research

Potato Seed Systems in the Highlands of Ethiopia

[1]Gebremedhin Woldegiorgis, [1]Atsede Solomon, [2]S Steffen, [3]Semagne Asredie, [4]Gebrehiwot Hailemariam
[1]Ethiopian Institute of Agricultural Research, Holetta Agricultural Research Center, P. O. Box 2003; [2],[4]Potato Project; [3]Amhara Regional Agricultural Research Institute (ARARI),
P. O. Box 527, Bahir Dar, Ethiopia

Introduction

Most of the agro-ecologies in Ethiopia have favorable climatic and edaphic conditions having a huge potential to produce high quality and virus-free seed potatoes. Potato can potentially be grown on about 70% of the arable land in the country (FAO, 2008; Solomon, 1989). Despite the availability of such extensive suitable agro-ecological conditions, the level of potato production and productivity has remained low with a national average yield of 8.2 t ha^{-1} (CSA, 2010) although farmers using improved seed and crop management practices produce between 19 and 38 t ha^{-1} (Gebremedhin *et al*., 2008).

Lack of sustainable potato seed system has been a major problem in the diffusion of improved potato varieties and expansion of potato production in Ethiopia. There is no government or private company, which produces and distributes seed potatoes in the country. Farmers therefore, resort to the available local varieties which are susceptible to many diseases and produce very low yield as the result of mainly degeneration of the seed tubers, modified planting time, etc. Potato seed transported from long distance is very expensive, requires intensive management and it may not reach at an optimum physiological condition at the place of destination. The crop is also very bulky and highly perishable that requires care in handling, especially under the Ethiopian condition where farmers are forced to keep the seed for more than six months for the next planting season. Therefore, potato seed production requires special focus due to mainly viruses and other biotic factors affect the quality of the seed materials.

Since the start of the national potato research in 1975, a large number of germplasm were introduced and considerable efforts were made to develop and release varieties for different purposes and improve traditional production practices of small household farmers. The adoption of improved seed in Ethiopia has generally been very low, official estimates suggest that in 2007/08 improved seeds were grown only on 3.4% of the total cropped area (12.4 million ha); in the case of root and tuber crops the area was only 1.2% or 2,251 ha of the total area of 184,000 ha (CAADP, 2009). Therefore, there is a strong need to improve existing seed systems to increase farmers' access to quality seed at affordable prices and in a timely manner.

Therefore, the purpose of this paper is to describe the current status of the existing potato seed systems, to identify the achievements so far and the gaps and finally to suggest the way forward so as to improve the national potato seed system.

The Current Seed System

Recently, potato has become a very important non-cereal staple in Ethiopia and is increasingly gaining importance as a food security crop owing to its ability to produce more edible energy and protein per unit area and time than most cereal crops. It has the correct balance of protein calories and total calories and thus considered to be a good weaning food. It is also suitable for intensive cropping systems.. Here, productivity is compared in terms of the number of people whose energy and protein needs are satisfied per ha and day of crop growth. Based on 2005 yield data (CAADP, 2009), potato produces around twice as much energy and protein than tef and clearly out yields wheat and barley. Given the large gap between actual and potential crop yields in Ethiopia as well as supportive government policies for the promotion of improved production technology, it is very likely that crop yields are going to increase substantially in the coming years. For example, national average potato yields are currently 8.2 t ha^{-1} (CSA, 2010), however, Gebremedhin *et al.* (2008) reported that farmers using improved seed and crop management practices produce between 19 and 38 t ha^{-1}. It is therefore very likely that the productivity of potato, compared with that of major cereals is likely to increase.

Apart the crop being a highly productive, it has an additional advantage that it is less exposed to price fluctuations since it is not a globally traded commodity. For example over the period from 2005 to 2008, farm gate potato prices in Ethiopia increased by 107% from USD 97 to 202 while the price for wheat increased over the same period by more than 160% from USD 202 to 528 (FAO, 2010). This highlights the crop's potential to dampen food price fluctuations and to provide a low cost food alternative in times of rising and unpredictable food prices.

Increase in potato acreage and yield calls for improvement of the quality of seed potatoes supplied to the ware potato production systems. This requires the improvement of the seed potato systems operating in the country.

According to Endale *et al*. (2009), potato seed systems in Ethiopia can be classified into formal and informal, on the other hand, Adane *et al.* (2010) reported a third type of potato seed systems suggested as alternative. This system supplies seed tubers produced by local farmers under financial and technical support from NGOs and breeding centers. Seed systems can be defined in the way farmers produce select, save and acquire seeds (Sthapit *et al.,* 2009). In the absence of a commonly agreed on terminology for different seed systems, this paper will follow formal and informal systems

The Formal Seed System

The formal seed system cover seed production and supply chain operated by public or private sector ruled by defined methodologies, with controlled multiplication, and in most cases regulated by national legislation and international standardization methodologies According to Gildemacher *et al.* (2009), in Ethiopia only 1.3% of the total potato seed requirement is met through a formal seed system characterized by relatively high quality, originating from basic seed produced by the national research system.

The Informal/Farmer-Based Seed System

The informal system is characterized by the absence of a formal certification and quality control mechanism and seed is being produced and distributed mainly by small-scale farmers. This seed system exists in all potato growing areas of Ethiopia, and is the major seed potato system (Adane *et al.,* 2010). According to Gildemacher *et al*. (2009), informal

seed system supplies 98.7% of the seed tubers required in Ethiopia. The seed tubers are sourced through an informal system whereby poor quality seed derived from farmers' own fields, saved from previous harvest, local markets or neighbors is planted. The seed tubers supplied by this system is known to be poor in quality, in terms of seed size, sprouting, physiological age, varietal purity, disease and pest attack, etc. This practice has contributed to the build-up of high level of viral and tuber-borne diseases in the locally grown cultivars. Farmers practice saving of potato tubers from previous season was one of the reasons for carryover of devastating diseases like bacterial wilt, viral and other seed borne pathogens which contributed for low potato yield (Barton *et al.,* 1997; Nyangeri *et al.,* 1997; Michieka, 1993) that resulted in potato shortage of seed tuber. A survey report by Gildemacher indicated that half of the potato farmers in Ethiopia leave their produce in the soil that will later be used as seed. This apparently is the method farmers prefer to store seed potatoes until the next season.

Given Ethiopia's large size, the rugged terrain and still limited road infrastructure and prohibitively high costs for a formal certification system, it is unrealistic to assume that the market share of the formal seed system can be increased substantially in the medium term. Therefore, the informal seed system will therefore remain the dominant seed production and dissemination practices in the country for the time being.

Challenges in Availability and Utilization of Quality Seed Potato

The national capacities to deliver disease free potatoes seeds of the desired varieties at timely and affordable prices are very weak all along the seed chain. The weakest links however are due to the nature of the crop, seed regulation, lack of proper planning, inefficient marketing and transportation system, poor linkages between partners, under-financing, lack of sufficient trained personnel and limited private sector/investor involvement in the sector.

The Nature of the Crop

The conventional multiplication rate of potato is very low compared to cereal crops, which is about 1:10. On the other hand, the crop is bulky and therefore expensive to store and transport, hence high cost of

production. Potato requires very high seed rate and depending on the size of the tubers between 1.8 and 2.2 t ha^{-1}. This makes the crop very difficult in transportation which also brings high storage, physiological and transportation losses.

High Degeneration Rate

Small-scale farmers usually use the small tubers saved from their last harvest as seed for their next planting which results in a build-up of diseases. If the seed potatoes are re-used from the own crop over and over again the yield will decrease over the seasons. This is called 'seed degeneration'. It is the result of a build-up of diseases, which passed on through the tubers because of replanting tubers infected with viruses, bacteria wilt or other seed-borne diseases.

Disease and Pest Transmission through Seed

Seed potato production requires research support to generate useful information in various aspects such as the incidence and geographical distribution of viruses and their aphid vectors. Potato pest and disease problems emerged as prominent issues in every chain of the seed potatoes. The frequency of mention of the pests and diseases as important issues underscores the need for continuous resistant breeding and dissemination of new varieties to farmers. It calls for need to repeatedly clean existing varieties of acquired pests and diseases and to maintain germplasm collection in anticipation of new emerging problems and to satisfy changing end users needs.

Seed Regulation

Although there is an encouraging agricultural policy in the country and high priority is given to horticultural crops, the seed standard and certification system is not in place to regulate the quality of seeds and planting materials of those economically important horticultural crops like potatoes.

Opportunities for Improved Seed System

Environmental Conditions

Ethiopia has conducive climatic and edaphic conditions for higher potato production and productivity. A large proportion of the cultivated land in

most of the agro-ecologies is suitable for the production of potato early canopy development and expansion and successful tuber growth in the soil (Berga *et al.,* 1994b). The major part of potato production is located in high altitude areas that are not suitable for the development of virus and aphid populations which enables the country to produce high-quality and virus-free seed potatoes. The existence of diverse agro-ecology has enabled nearly a year-round potato production in the country. Proper utilization of such an opportunity will not only boost the national potato production but also help the country to earn more foreign currency by exporting quality seed potato to other countries (Endale *et al.,* 2008).

Policy

The government of Ethiopia is rigorously working towards doubling the agricultural outcome within the five years plan. This can be achieved by using high-yielding crops and crop varieties such as potato and expansion of irrigation. Given the large yield gap between average national crop yields and yields obtained under on-farm conditions with improved seeds, the government of Ethiopia has identified the need to improve existing seed systems as one of the most effective means of meeting these objectives (CAADP, 2009). Production and processing of horticultural crops, vegetables and fruits have been placed in high priority list areas and various investment incentives have been provided by the Government to encourage the development of the sector.

Marketing and Utilization

The utilization of potato in Ethiopia has been very conservative. In recent years, however, the consumption of potato in the form of crisps, chips and mixture of salads, stew and porridge has dramatically increased. The increase in urban development and improvement in infrastructure such as road has opened a growing opportunity for potato growers to sell their potatoes to nearby towns and distant cities. Some quantity of potatoes is also exported to Djibouti, Sudan and also to Middle East countries (Gebremedhin, 2008).

Labor

Potato production is labor intensive. The availability of extensive family labor in the country is another important opportunity for potato production.

Facilities

There are modest tissue culture laboratories at Holetta, Bahir Dar and Mekelle, while another one is under construction at Areka. Diffused light stores which are useful to store potato seed tubers are also available at different research centers and on farms. At Holetta and Adet Research Centers, insect-proof screen houses are also available to grow clean potato minitubers. Moreover, aeroponic units are built at Holetta Research Center to help boost the production of healthy potato planting materials. Using the existing units, it is possible to produce about 80,000 pre-basic potato minitubers of 1 to 20 g during two cropping cycles per year.

Achievements and Experiences

Efforts are undergoing in strengthening seed production programs. The use of informal seed tuber production has been implemented in the last few years in collaboration with stakeholders. This system was found as best alternative in developing countries where there is no formal seed production system.

A considerable progress has been made in relation to development of varieties, agronomic and seed production techniques, and integrated pest management (IPM) for major diseases and insect pests in different agro-ecological zones of the country since the establishment of the national potato research program. A participatory potato technology development and dissemination was under taken mainly in the central highlands of Ethiopia since 1998 (Gebremedhin *et al.,* 2006). The Methods used on-farm variety adaptation trials, farmers field schools (FFS), farmers research groups (FRG), informal seed production, trainings at different levels in collaboration with MoA, NGOs and farmers, with the objectives (i) to bring the technologies closer to farmers for dissemination (ii) to involve farmers in evaluating materials for easier adoption and (iii) to bring together the different stakeholders in potato development program.

The farmer field school (FFS) was run from 2000-2007 in collaboration with CIP. It was found to be an appropriate method for participatory training, research and dissemination of technologies. This approach had increased knowledge of farmers' understanding of potato diseases and pests and their management.

Over 2000 tons of potato seed tubers were produced at different farmers' fields from 1999 to 2005 (Table 1). Since the farmers who grow seed potato were trained on the construction of DLS, 152 seed stores ranging in capacity from one ton to 15 tons were constructed in different weredas. Knowledge of farmers on production and management of healthy seed potato production has improved and farmers in the project sites have become the main source of improved potato seed tuber in the country.

Table 1. Quantity (tons) of different varieties of seed potato grown at different localities

Woreda	Year					Total
	2001	2002	2003	2004	2005	
Jeldu	32	88	93	274	358	845
Welmera					903	903
Degem				51	510	561
Total	32	88	83	325	1771	2309

Source: Gebremedhin et al., 2006

Potato tuber yield and incomes obtained from sales as seed and ware tubers in West Shewa and Gurage Zones with variety Jalene in 2009 show that seed potato enterprise is profitable (Table2). The amount of money obtained from potatoes is still much higher than from other staple crops even if the whole produce is sold as ware at a much lower price because of the high yields of potato. The benefits could have been higher if all the produce is sold as seed.

Table 2. Yield and income per hectare from sale of Jalene potato variety as seed and ware in West Shewa and Gurage Zones, 2009

Zone	Wereda	Yield (t ha^{-1})	100% seed Birr 6000 t^{-1}	100% ware Birr 3000 t^{-1}	50% seed 50% ware
West Shewa	Chelea (Avg. 4 FGs)	22.6	135,600	67,800	101,700
	Tikur Inchini (Avg. 4 FGs)	12.9	77,400	38,700	58,050
Gurage	Gumer (Avg. 3 FGs)	44.9	269,400	134,400	202,000
	Geta (Avg. 2 FGs)	40.7	244,200	122,100	183,100

Avg. = Average; FG = farmer group
Source: Common Fund for Commodity (CFC)- Funded Wealth Creation Project report, 2009

One of the efforts done to disseminate the farmers based informal potato seed system was to decentralize the seed sources in different regions after selecting potential areas suitable to grow healthy potato seed. This practice was favorable to facilitate the availability of relatively healthy seed at affordable prices and in a better condition than that of seeds

transported from a distant area. In line with this, EIAR in collaboration with Tigray Agricultural Research Institute (TARI) and Amhara Agricultural Research Institute (ARARI) started a pilot study at Atsbi in Tigray Region and at Chilga and Awi Zone in Amhara Region. From these pilot sites, the promotion of farmer-based potato seed system, showed an encouraging results.

At Atsbi, 15 ha of land is planted by farmer groups in which most were sold as seed and one cooperative is established with 34 members. Now most of the farmers are aware of the adoption and supply of improved technology and good quality starter planting material increased seed potato production and potato productivity in the region that subsequently improved the income of farmers involved in potato seed business.

The Atsbi experience has proven the possibility of supplying quality seed at profit. The organization of potato seed tuber growers in to cooperative have assisted them in facilitating the collection and selling of their produce and improve their bargaining power.

Income of the farmers who participate in the CFC project increased from the sale of potatoes either for seed or ware. For example seed growers in Tigray region in Atsbi district of Felegewoini seed potato growers association sold ETB 445,620 (310,500 from main-season harvest and 135,120 from offseason harvest). The farmers have saved more than ETB 285,120 in bank account the rest have been distributed for private use. More than 17 of the 34 members have bought motorized water pumps. Farmers who grow potato either for seed or ware after they involved in the CFC project in Wenchi Woreda earned more than ETB 1.64 million in three cropping seasons out of which more than ETB 1.22 million was from 2010 season's sale. The farmers have witnessed that the quality of their living standard in terms of housing, sending their children to school (have managed to pay school fee without problems), clothing, etc. improved due to involving in seed production activities

The same activity was also replicated in Amhara Region, where more than 43% of the countries potato production comes from and the productivity is below the country's average. The activity was started at Chilga Woreda and the promotion work was handled by Adet and Debrebrhan Research Centers (Table 3)

Table 3. Potato seed producers and amount produced in Western Amhara, 2005-2007

Zone	Woreda	Year					
		2005		2006		2007	
		No. of producers	Amount of seed produced (t)	No. of producers	Amount of seed produced (t)	No. of producers	Estimated Amount of seed produced (t)
South Gonder	Lai Gayint	2	1.2	3	4.5	5	15-20
South Gonder	Tach Gaint	-	-	-	-	23	7.3-10
West Gojam	Yilmana Densa	6	13.0-13.5	5	60.4-65.4	14	199-248.8
Awi	Banja and Guagusa	2	1.0	8	20	115	210
	Total	10	152-157	16	84.9-89.9	157	431.3-488.8

Source: Yalfal et al, 200.

The Way Forward

Interventions designed to improve farmers' access to quality seed at affordable prices should therefore aim building upon the existing informal system, trying to improve seed quality and overall system efficiency. The system enables farmers get appropriate improved varieties, relatively healthier & sound seed potatoes than the local varieties and seed at an appropriate physiological age for planting. The system could also serve as a means of disseminating improved potato technologies to farmers.

The most important characteristic of a seed potato is its quality and the quality characteristics of potato seed are as follows:

Availing Sufficient Quality of Healthy Potato Seed to Farmers

A higher health standard is required than for certified seed that is used for the immediate production of ware or starch potatoes.

An integrated seed strategy would be to teach farmers to select best of their own seed, use it for three to five years and replace it with new clean seed. National programs and private suppliers of quality seed would have the task of providing enough seed each year to satisfy this demand at an appropriate cost. Both informal and formal seed systems have separate roles towards meeting the seed needs of the potato growers. The formal seed system is expensive and not yet well established to satisfy the demand, it is necessary to seek ways to make the informal system perform better using available technologies. Support to formal systems to make the seed potato more affordable would also be worth pursuing.

Demonstrations among farmers would be helpful in widening their awareness on how seed health and quality features relate to superior tuber yields. Nearness of the source of clean seed to the majority of farmers will encourage farmer the use of such seed. Availability of pre-basic and basic seeds from the formal system can be improved through training of NARs staff and the private sector, introduction of novel rapid multiplication methods such as tissue culture and aeroponics and through improved laboratory diagnostic capacity.

The availability of quality seed in the informal system can be increased through capacity building by training of stakeholders to improve their

skills on small seed plot techniques to raise efficiency of seed supply, positive and negative selection methods to improve the quality of seed and knowledge of diagnostics support to determine when the seed requires virus cleaning while in cultivation, or when a new disease emerges. The government recognition of potato seed crop value chain as a priority is also important in setting up of favorable policies that help to sustain the seed system.

Working in Partnership

Improved advocacy among political leaders, policy makers, researchers and donors is recommended to highlight the economic value of potato as a measure to encourage investment.

Standards, Seed Inspection and Certification

The performance of public functions of seed inspection, certification and coordination for sustainable potato seed systems is crucial.

Capacity Building

Capacity in terms of skilled personnel and facilities like screen houses, TC laboratory and cold store helps the production of healthy seed tubers and the process of quality inspection.

Initiate Activities to Begin Formal Potato Seed System

Close to absolute dominance of informal over formal seed systems is a common feature at present in the country. Under a formal seed system national organizations or companies, under national legislation, provide the different categories of farmers with seed of superior genotypes appropriate to the farmers' purposes; in an appropriate physiological state, vigor and health; in sufficient quantities; at the right time; and at an affordable price (Gibson *et al.,* 2009).

Improve the Quality of Informal Potato Seed Systems

Under informal seed systems, farmers function, without public regulation, to provide seeds for their own planting or for exchange, sometimes through the market mechanism. Since the informal system is not publicly regulated, the quality in terms of health and varietal purity of seed, which the system provides is not guaranteed.

Following Improved Seed Schemes

Decentralized seed production and multiplication system that links producers of pre-basic minituber with a decentralized, farmer-based seed multiplication and dissemination system, thereby creating a new hybrid system that incorporates components of the formal as well as informal seed systems is important. The initial source materials are disease-free in-vitro plantlets produced by the national research system and private tissue culture laboratories. These plantlets are grown in screen houses or the newly built aeroponic units to produce pre-basic minitubers (Generation 1). Generation 2 which are derived from aeroponics will be further multiplied at screen houses and at fields at research center to have enough planting material for further multiplication. Given the small size of the pre-basic minitubers, these should then be multiplied by experienced seed potato producers with under semi-controlled conditions; especially access to irrigation is an important requirement. These experienced multipliers include research centers, private enterprises and leader farmers, ideally located at head points of traditional seed systems. The produced Generation 2 seed is then sold to seed producer groups/private multipliers who in turn may sell the subsequent generation to surrounding farmers, seed producing groups and private sector multipliers through farmer-to-farmer exchange. It is assumed that for the first two generations the entire produce would be kept as seed, however, as of generation three it is likely that an increasing proportion of the produce will be sold or consumed as ware immediately after harvest so as satisfy farmers need for cash and food. At this point in time it is difficult to assess for how many generations the seed will be recycled before being used as seed for ware thereby reaching the consumer as ware potatoes.

Farmer groups and leader farmers located in these seed producing areas play a key role in producing quality seed, catering for their own seed needs and providing seed to other growers operating in that area. Such a system requires more input /resources initially, however, once established, it drastically reduces transaction costs and dependence on outside intervention to function in a sustainable manner. The small pre-basic minitubers (5 to 20 g) ideally complement such a system since they can easily be transported to remote multiplication sites located at head points of these seed flows. This again greatly reduces potential transport bottlenecks of more centralized systems. For such a system to make best

use of these expensive minitubers, it is important that the head points of these seed flows are located at high altitudes where disease pressure is greatly reduced. Subsequent seed generations should then gradually move to lower altitudes and ware crops can be grown in the lowlands. Seed quality control from in-vitro plantlets up to generation 2 seed would be carried out by the national research systems. In subsequent seed generations, seed producer groups would maintain seed quality through a system of peer pressure and social control whereby group members who do not adhere to agreed on quality control measures such as rouging would be expelled from the group. First experiences with such a peer-group quality maintenance system are encouraging and could be scaled up.

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