Tackling Low Potato Yields in Eastern Africa: an Overview of Constraints and Potential Strategies

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Introduction

Improvement of the potato production system in sub-Saharan Africa (SSA), where potato is an important cash and food crop, can be a pathway out of poverty. Potato has a short cropping cycle and a large production per unit area in a given time. It provides more nutritious food per land unit in less time and often under more adverse condition than other food crops due to its efficient water use. It is one of the most efficient crops in converting natural resources, labour, and capital into a high quality food. Potato is a cash crop of the future for the densely populated East and Central African highlands, with a high potential to raising the livelihoods of smallholders. Furthermore, potato provides a cheap but nutritionally rich staple food required in the fast growing cities of SSA, contributing protein, vitamins, zinc and iron to the diet.

For SSA, (Scott *et al.* 2000) projected a 250% increase in demand for potato between 1993 and 2020, with an annual growth of 3.1%. The growth in area under production is estimated at 1.25% a year, the rest of the increase being achieved through predicted growth in productivity. For both increased productivity and area under production, a well-timed availability of good quality seed of improved potato varieties will be vital, which is also a very efficient way of promoting adoption of high yielding, disease resistant potato varieties that have acceptable qualities for both table and processing. Increased potato productivity will play a buffer role to the increasing food prices and thus enhance household income in the project countries with a spill over to other countries in SSA.

Major Constraints and Strategies for Increasing Potato Productivity in Eastern Africa

Current average potato yields in Sub Saharan Africa stand at 7.8 tons per hectare (FAO, 2012). Yields of 25 tons are, however, being attained by progressive farmers using best production practices, under the same rain-fed conditions as their neighbours who attain yields of 5-6 tons per hectare. This yield gap can be

attributed to the use of low quality seed potatoes (Kinyua *et al.*, 2001), low yielding varieties, poor disease management (Olanya *et al.*, 2001), and inadequate soil fertility management (Lemaga *et al.*, 2001).

Low quality seed

Availability of good quality seed in the region is very limited and hence most farmers use seed, either from their previous harvests or from local markets, whose source is not well known. Such seed is usually diseased and or physiological in poor state, resulting in very low yields. The few farmers that access good seed of improved varieties harvest may double their yield compared with their neighbours (although good data remains lacking in many cases). Many farmers, being aware of such advantages are willing to pay premier prices for better quality seed of improved varieties produced by public institutes or recognized seed growers, but are constrained by the acute shortage of such seed. Moreover, traditionally with the National program whole cycle of producing certified potato seed, typically takes 5-7 seasons and the potato seed stocks inevitably accumulate seed borne diseases such as viruses or bacterial wilt through each cycle.

Therefore, the International Potato Center (CIP) has developed, and with its national partners, tested the components of an innovative seed strategy, which both dramatically lowers the cost of production of pre-basic or "starter" seed coupled with extension based interventions to train smallholders in the better on-farm management of their own seed. A more efficient and responsive seed system will improve production, distribution, use, and profitability for farmers. Promising rapid multiplication technologies, the "3G revolution," and an engaged private sector can provide needed capacity to broaden adoption of quality seed and accelerate availability of new varieties with more prospect of benefit. Better integration of national agricultural research and extension systems into the value chain; as well as farmer training schemes in seed management and storage, can accelerate innovation. A regional perspective can help exploit economies of scale for sharing knowledge and technology, implement creative applications of information communication technologies, advocate for farmer-friendly seed-related regulations and policies, improve the business enabling environment, and expand intra-regional trade for seed of the highest categories. The International Potato Center (CIP) has produced a Roadmap document having a five-year strategy described for Ethiopia, Kenya, Rwanda, Tanzania, and Uganda targets business investments in key areas along the seed potato value chain to increase the availability of high-quality seed potatoes from less than 1% to at least 5% of demand (except Kenya, where the target is 10%) and promote improved seed

management. This will raise incomes of smallholder farmers, improve food security, and add to the rural and growing urban economies in these five countries.

Five mutually reinforcing core investment areas (IAs) are proposed to put the interventions of seed potato value chain into practice. Three IAs make up country-level business plans:

- Improving quality seed production and distribution;
- Enhancing profitability of quality seed use; and
- Upgrading value chain coordination

Two IAs are regional and potentially cross-cut all five countries

- Promoting regional networks for sharing knowledge and best practices
- Growing intra-regional trade in seed

The IAs build on a mix of value chain fundamentals and the accomplishments and lessons learned from recent projects, such as the two-year, USAID-funded 3G project. Led by CIP and implemented in Kenya, Rwanda, and Uganda, the 3G project increased access to and production of basic seed potato in both public and private sectors; successfully introduced aeroponics technology and supported its adaption and adoption; and significantly increased production of minitubers at the national and regional scales. The project fostered private adoption of the three-generation (hence the "3G") seed multiplication strategy and improved knowledge and skills leading to average yield increases of 20% for over 15,000 smallholder growers on potato production technologies and best practices. Other seed-related projects have generated complementary experience with improving farmer seed management that can be scaled up, such as the Common Fund for Commodities (CFC) project in Uganda, Kenya, and Ethiopia, USAID funded "Better Potato for a Better Life" project in Ethiopia and the Irish Aid-funded project in Malawi. The investment proposed in the Roadmap is expected to direct the increase in yield of 20% in the five target countries to achieve three overarching objectives: a 15% increase in farm incomes, improved food security through a 10% increase in potato production, and more business opportunities for at least 240,000 households of smallholder potato growers.

Low yielding varieties

Most of the varieties (Many of CIP origin) being used by farmers in the region were released in the 1990s, which in the process have either degenerated or lost their resistance to important diseases such as the potato late blight.

Another important quality of many new varieties is virus resistance. This will greatly facilitate the value-enhancement of new seed discussed above and make seed production easier and therefore more profitable. There are many other characteristics that new potato varieties can bring to small-scale farmers including variation in maturation periods and dormancy period—allowing more flexible planning—resistance to drought, and greater yield stability. Some qualities come unknown to farmers as breeders are now selecting varieties with higher nutrient value. Most potatoes produced in eastern Africa are consumed fresh. Nevertheless, with population doubling every 25 years and urbanization predicted to grow by 13% in the next 10 years, consumption patterns are rapidly changing in favour of easy-to-prepare foods such as chips (French fries). There is high potential for the growth of the potato processing industry, and market access in the region is improving with increased demand for both fresh-cut and frozen potato chips. CIP and partners are involved in the development of new varieties that combine processing quality with one or more of the robustness characters mentioned above. Although several new varieties have been released since then by the joint effort of CIP and National Agricultural Research Institutes (NARIs) in the region, these have not been adequately adopted by farmers due to shortage of seed and poor promotion strategies and approaches followed in the region. This can be attributed to several reasons

- Lack of demand for seed may be an issue in the case of new varieties because of an inadequate supply of information on their advantages. Thus, farmer awareness is an important element in adoption of new varieties;
- Potato inherently has a low multiplication rate (about 10 seed tubers per plant) and potato seed is bulky and perishable;
- Lack of investment in National programs, “land-grabs” and consequent loss of key land for seed multiplication like for instance in Kenya and rising fuel prices have all contributed to this situation;
- The current practice of potato variety release mechanisms in Eastern Africa are focused primarily on high-input agriculture. While this fits some of the farmers in the region, most farmers work under low input conditions and the relative responses of varieties is not consistent across input regimes. Some varieties are known to be good scavengers for nutrients and may provide much better yield stability to low-input farmers. Policy

makers should take this into consideration and a two-tiered evaluation system may be needed; and

- Harmonization and shortening of evaluation and selection processes would be key for accelerated release of improved germplasm. Much of the region have similar environmental conditions, and a similar spectrum of biotic constraints, which means that with certain exceptions, the performance of a particular potato variety can be expected to be similar in all parts of the region. For this reason, potato workers in the region have long discussed the need for harmonized policy across the region that would facilitate rapid release of new varieties. The primary mechanism for this would be the use of trial data from one location in other parts of the region. To date, this has happened to a limited extent, but a formal structure for sharing of data across the region has not been fully implemented yet.

High incidences of diseases

High incidences of late blight, bacterial wilt (BW) and viruses affect potato production in Eastern Africa. The high incidence of these diseases in the region ensued from the lack of good seed system, inappropriate use of chemicals to control fungal diseases and lack of proper sanitation, crop rotation, and varietal resistance among other factors. The incidence of viruses and bacterial wilt is very much linked with the general lack of clean seed.

Potato late blight (LB) is the most important plant disease because it causes severe, direct crop losses virtually the world over. Typically, small-scale farmers continuously use fungicides to combat LB, but this practice creates a dependency on pesticides and compromises human health and the environment.

The control of LB implies actions on different fronts, so any project that targets the disease should consider using an interdisciplinary approach to tackle this problem. Decades of research into LB at the International Potato Center (CIP) suggest at least five key areas of effective intervention

- Design and conduct baseline, risk, and impact assessments to better quantify the problem, provide a strong foundation for improved decision making by stakeholders, and demonstrate outcomes and impacts;
- Enable appropriate disease management for small farmers: combining state-of-the-art scientific information with farmer knowledge will improve LB management practices;
- Improve development of durably resistant cultivars with market appeal. Resistant potato varieties constitute the cornerstone of the LB control

strategy, particularly for resource-poor potato growers who cannot afford intensive fungicide use;

- Maximize impact by rolling out these intervention tools through farmer capacity building; and
- Opportunities to involve the private sector as well as create public-private partnerships (PPP) as variety users need to buy into sustainable low-pesticide potato. PPP opportunities also exist in quality seed production and novel control options such as phosphonate-based fungicide control.

Farmers identified BW as a major threat to intensive potato production in the East African highlands (Gildemacher et.al., 2009; Turkensteen, 1987). The BW problem is expected to increase because of shorter rotations and low seed quality. The disease survives in the soil for several seasons. Hence, one essential component of BW management is denying the bacteria a host by not growing potatoes or any other host crop for several seasons, combined with a strict removal of volunteer potato plants (Lemaga et al. 2005). In this respect, the effect of organic and inorganic soil amendments and the evaluation of antagonistic agents in BW control should be investigated more closely. Likewise, the efficiency of local crop rotation system should be tested in respect to their contribution to BW control and farm income.

The management of BW is further complicated by the lack of reliable seed sources and the heavy reliance on farm saved seed potatoes as planting material, which results in frequent reinfection of fields. The bacteria survive in non-symptomatic tubers that are stored for future planting; making them to vectors for the infestation of new fields, they are planted. Therefore, BW control has to include a seed potato quality management component, reducing the use of infected seed. Moreover, tools have to be developed for more accurately, easy to use and cost effective detect and quantify BW inoculum in soil, seed and water, to help National Programs and extension services in reducing losses caused by the disease.

Inadequate soil fertility management

An adequate soil fertility and crop management are not only key components for sustainable crop production in potato based cropping systems but also decisive factors to increase productivity and crop quality. Especially in SSA the gap between actual and potential yields is caused to a great extent by insufficient nutrient supply to the crop and nutrient mining of the soil. This situation aggravated by a crop like potato which has a high nutrient demand but a low nutrient recovery rate. The negative effects are felt more strongly in practices that use little crop rotation. For farmers to invest in potato production there should be a

convincing benefit that the potato brings against other competing crops. This call for a reliable market for potatoes, which potentially exists but needs to be systematically enhanced in a value chain approach. Furthermore, soil fertility management also stimulates microbial soil life and decomposition processes, which in turn decrease the incidence of soil or seed borne diseases such as BW. Ethiopia as an example, faces a wide set of soil fertility issues that require approaches that go beyond the application of chemical fertilizers– the only practice applied at scale to date. Core constraints include topsoil erosion, some sources list Ethiopia among the most severely erosion-affected countries in the world, along with Lesotho and Haiti. Acidity-affected soils covering over 40% of the country significantly depleted organic matter due to widespread use of biomass as fuel, depleted macro, and micro-nutrients, depletion of soil physical properties, and affecting soil salinity.

Four areas in which significant improvement in on-farm practice will yield substantial production gains are:

- Severe organic matter depletion, driven by competing uses for crop residues as livestock feed and manure as fuel. The use of dung as fuel instead of fertilizer is estimated to reduce Ethiopia's agricultural GDP by 7 percent;
- Severe topsoil erosion of up to 10-13 mm per annum or 137t/ha/year;
- While crop rotation and fallowing have implementation challenges related to food security and the small size of land holdings, intercropping does not face these same challenges, yet current use are nearly non-existent. This is mainly due to the limited use of basic practices and benefits; for example, minimum tillage, and soil and water conservation); and
- Limited use of integrated, locally tailored solutions. Required enablers (for example, robust, simple soil diagnostic tools) are not widely available outside of research projects. These interventions are constrained by a lack of up-to-date data; many interventions depend on major national soil surveys dating to the 1980s (FAO) and macronutrient studies from the1950s–60s. In addition to the lack of actionable, relevant data, the weak linkages between research and extension inhibit the adaption and adoption of these practices by smallholder farmers.

Specific to fertilizer, there are a set of value-chain constraints

- Chemical fertilizer faces significant constraints in terms of low availability of credit and limited reach of distribution networks in contexts where appropriate application can enhance yields;

- Bio-fertilizer is constrained by low demand, due to lack of awareness and understanding of the product, and limited production capacity. Extensive testing of benefits to identify appropriate products is needed; however, research efforts are currently limited; and
- Inadequate use of farm manure and other on-farm organic matter resources like crop residues

Inadequate seed and ware potato storage facilities

Technologies for storing seed and ware potatoes were developed by CIP long time ago, but their adoption in the three countries has been below expectations. In Uganda; however, AfriCare, an International NGO, has helped spreading the use of diffused light stores (DLS) for storing seed potatoes in the woredas of Kabale and Kisoro. All the members of the Uganda National Seed Potato Producers Association (UNSPPA) also built their own stores that have bigger capacities. The Ethiopian potato program has also had much success in promoting the adoption of DLS through its competent extension activities. In Kenya and Rwanda, a few farmers store seed potatoes in DLS.

Generally, however, the majority of the farmers store seed from their previous harvests in piles on the floor of their houses or in sacks or baskets, resulting in poor and usually long sprouts that break easily during transportation and/or planting. Such poor storage practices result in one sprout per tuber due to apical dominance, leading to one stem per plant and hence very low yields.

Experience has shown that raising awareness of farmers of the benefits of DLS will highly increase its utilization in the three countries with consequent results of increased per unit area yield. Moreover, if seed farmers use DLS, they can get much higher incomes from sale of quality seed to ware potato producers.

Besides seed potato storage, proper ware potato storage systems are of major importance to improve the value chain. One of the major constraints to increased year-round utilization has been insufficient post-harvest management systems. Post-harvest losses due to mishandling can be as high as 30% (Gebre et al., 2008).At harvest time, there is a problem of glut, which leads to very low prices (discouraging farmers) at times of abundance, and very high prices (discouraging consumers) at times of scarcity. Data from Ethiopia shows that farm gate prices fluctuate by more than 25% within 2 months before and after harvest (CSA, 2012). Unstable pricing and seasonality of supply also discourages agro-processors from investing in these value chains. Improvement in post-harvest management would expand the period of the potato availability for household consumption, providing

valuable micro- and macro-nutrients for 4-6 additional months per year and increase marketing opportunities. Several technologies already exist and have been tested on a small-scale in SSA. What is lacking is widespread testing and if needed, adaption to new conditions in different countries, and then going-to-scale to ensure farmer access to these technologies. As urbanization proceeds apace in SSA, reduced postharvest losses will be key for potato to continue playing a major role in food security and being a good source of farm income across the continent. Technologies for reducing postharvest losses include reduction of physiological deterioration, increasing knowledge on appropriate transport techniques, reduction in percentage of tubers with insect and other damage, storage facilities, and market information for timely delivery and use.

Conclusions

A set of constraints along the potato value chain has to be considered simultaneously, to ensure higher yields, better income, and a significant contribution of potato farming to food security and improved livelihoods in the region. High yielding potato varieties have to be released that have good resistance to late blight and low degeneration rate as well as good table and processing qualities. These varieties should have wide adaptability, with a potential to produce well in the region. If seed of these varieties is available to growers, using rapid multiplication technologies there is a great potential to boost potato productivity and production, especially if these are coupled with best cultural practices like soil fertility management and disease control measures as well as with ware potato storage technologies.

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