The potato seed system in the Republic of Georgia: a baseline analysis for a national integrated seed health strategy

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Summary

The present study was designed to provide information to improve the Georgian potato seed system, including risk assessment of pathogens and pests associated with the seed system. The objectives of the study were: i) characterize the current potato seed system and to a lesser extent the overall potato production system in a Georgia using available literature and expert elicitation (EE) methods; ii) list the primary potato varieties used in the country by region, and iii) map the distribution of major diseases across potato growing regions in Georgia based on results from expert elicitation. Experts divided the country in to three major production zones in the Northern Highlands, Midlands and Southern Highlands, with the most production in the South and Midlands. Seed sourcing is different in the three zones. In the north where there are no large farms, seed is self-saved or comes from local sources. In the South, some seed is imported from Europe and then distributed primarily to southern and midland farmers. The main diseases in the country are potato late blight and early blight, but some important quarantine diseases also occur, including potato wart, caused by *Synchytrium endobioticum*. Although many varieties are grown in the country, three of them, Jelli, Marfona and Picasso cover 50 % of the area.

Purpose of the study

At this time, the Georgian government would like to promote the production of certified seed within the country and is in the process of developing a seed plan. However, a robust characterization of the existing seed system as a whole, including numbers and types of farmers, sources of seed, traders, local seed producers, seed cooperatives, markets and also the primary biotic and abiotic constraints, has not been done. As this information would enhance development of a seed plan and associated policies, as well as providing evidence for research on potato plant health and pest and disease risks in the country, a workshop was planned to elicit information from experts familiar with potato production in Georgia. Information from the workshop was used in the development of this report.

Background

Seed systems

Planting material (hereafter referred to as seed), whether sexually or vegetatively propagated, is an essential component of any plant production system and the complete set of mechanisms by which producers may procure seed is often referred to as a seed system. Within the agriculture sectors in high-income countries, the term seed system is often used to refer to a commercial seed production system, generally accompanied by formal certification of seed quality, described in more detail below. It is important to remember, however, that seed may also be acquired informally by producing it on-farm or by sourcing from local markets, neighbors, traders, or decentralized multipliers (Thomas-Sharma *et al.*, 2015). Seed systems that provide seed of recognized quality based on minimum standards (e.g., certified seed) are often referred to as formal, while systems in which producers acquire without these controls are often referred to as informal. In this paper, the term 'seed system' is used to refer to all mechanisms of seed acquisition and/or on-farm production, whether formal or informal.

Healthy seed systems have been described as providing access to quality planting material, at the time needed, at a fair price, to all who need it (Sperling, 2008). A healthy seed system can act to reduce risk of disease outbreaks by keeping spread of a disease in check or even as part of a pest eradication plan. Conversely, seed systems without effective quality control can be very efficient at moving seed-borne pathogens. In areas lacking a robust formal seed sector, breeding programs, or national extension services, new epidemics can be particularly devastating because the system has no mechanism to react and adapt. Another important role of seed systems is in the diffusion of new varieties and the maintenance of crop diversity in the landscape (Pautasso *et al.*, 2013). In the case of a new or emerging pathogen in a region, the seed system acts as the conduit through which locally adapted resistant varieties can be distributed (if available).

Seed degeneration, a process through which yield is lost in vegetatively propagated crops through pathogen accumulation in consecutive cycles of propagation, is of particular concern to informal seed systems, like that of Georgia. Globally, seed degeneration is among the leading limitations to potato yield (Thomas-Sharma *et al.*, 2015). In high-income countries, which have the highest potato yields, this problem has been solved through the utilization of seed certified to have high quality (low incidence of pathogens, varietal purity and appropriate physiological age). This process has been highly successful for large-scale producers by providing access to economically priced seed of high quality. For smallholder farmers from low- to middle- income countries, such as the majority of farmers in Georgia, certified seed is often not available or the cost is prohibitive. Instead, farmers acquire seed of unknown quality via the informal system, either from the previous year's crop, or from other informal sources such as those mentioned above. In informal systems, degeneration is often a problem because seed is not tested and may be produced under conditions of high disease pressure with little or no quality control.

The Georgian potato seed system

The agriculture sector is vital for Georgian livelihood, supplying 45% of rural household incomes and 73% of rural imployment (Jashi, 2017), representing over 50 % of the total workforce (Bluashvili & Sukhanskaya, 2015). As of 2016, potato ranked highest in terms of annual crop production in the country (249 ths. tons), outpacing maize and wheat (*2016 Agriculture of Georgia*, 2017). Even so, the yield gap for potato in Georgia remains staggering. Yields vary greatly across the country due to variable agroecologies and farming practices, but average yields are estimated to be about 12 t/ha (*2016 Agriculture of Georgia*, 2017), compared to those in high-income countries that can be greater than 45 t/ha (FAOSTAT, 2015). Georgia's low productivity makes the nations potato production particularly vulnerable to the risks imposed by new and emerging pathogens and other system shocks and stressors. These risks need to be properly assessed to construct a framework to enable timely and systematic interventions.

The formal potato seed system in Georgia collapsed with the fall of the Soviet Union and has not yet been redeveloped (Carli C. *et al.*, 2010). Because of this, most potato farmers in Georgia, who are smallholders with less than 2 ha of land, source potato seed through the informal system described above. Potato production by most of these farmers is primarily for subsistence. Some larger farmers source seed directly from European producers, at a price that is cost-prohibitive for most small-holder farmers.

As noted above, one function of a healthy seed system is to maintain the phytosanitary status of the crop and reduce the risk of disease spread. Because of it's informal nature, the seed system in Georgia may be at particular risk for seed transmitted pathogens. One example disease of emerging concern in Georgia is potato wart, caused by *Synchytrium endobioticum*. During surveys conducted between 2010-2013, the pathogen was reported on several different varieties including Agria, Finka, Picasso and Marfona in multiple villages in Georgia in the southwestern highland region of Adjara (Gorgiladze *et al.*, 2014). It is believed that potato wart is primarily spread through infected seed potato tubers, making it a high risk for seed systems where there is little or no control of phytosanitary quality (Dehnen-Schmutz *et al.*, 2010). *S. endobioticum* is considered a quarantined organism and many countries have implemented strict regulation to prevent introduction (Obidiegwu *et al.*, 2014; Gagnon *et al.*, 2016). Once introduced, eradication of this pathogen is very difficult because the pathogen produces thick-walled sporangia that can persist in the soil for over 20 years (Hampson, 1993). *S. endobioticum* is an example of a devastating pathogen where long-distance dispersal is primarily human-mediated. Other major disease problems that have been previously reported in the country are viruses (PVY, PVX), *Pectobacterium* (*Erwinia)* spp., *Rhizoctonia solani*, and especially *Phytophthora infestans*, causal agent of late blight (Carli C. *et al.*, 2010). Nevertheless, disease reports have been sporadic in the literature and the underlying distribution of disease and severity across the country remains understudied.

Potato seed sector development is managed institutionally in the country by the Ministry of Agriculture (MoA) and particularly through its LEPS–Scientific MoA–Farmers' Extension Service Centers (FESC), in charge of farmer training, and the MoA–Grain Logistic Company (GLC), which is charged with seed production and field trials.

Methodology

Expert Elicitation Workshop

Participants were invited to attend a two-day workshop and were individually selected because of expertise in Georgian potato production and their broad representation of many sectors involved in the potato value chain. Forty-three representatives from different institutions participated, although there was some attrition the second day, which was Saturday. Data were obtained from the selected experts using an interactive modular survey instrument, specifically focused on assessing the major structure and disease risks in the Georgian potato production system. The modules were related to variety use, diseases, institutional involvement, stakeholder identification, transaction and information networks and other important risk elements. The following areas were addressed in the workshop:

Local stakeholder identification

Characterizing the seed system of an entire country is a non-trivial problem. To ensure a common set of assumptions, we asked the participants to identify major production regions for this analysis, keeping in mind agro-ecologies and farmer behavior. From this discussion, three production regions were defined and groups of actors were "lumped" together based on shared environments. For example, potato producers of certain agro-ecologies may behave similarly in their preference for varieties based on common environmental limitations to production (biotic and abiotic stresses, altitude, temperatures, water availability, cooking preferences, proximity to processing industry, etc.). Participants were asked to provide growing seasons and acreage for each group-identified regions. These regions were then used to frame questions through the remainder of the study.

Using the survey instrument and elements of the multi-stakeholder framework for intervening on roots, tubers and bananas seed systems (RTB, 2016; Bentley *et al.*, 2018), participants were asked to identify the relevant actors in each region. These were defined as small-holder farmers (<1.25 ha of potato produced last season), large-holder farmers (1.25-25ha of potato produced last season), local seed producers, traders, markets, local input suppliers, local grower cooperatives, seed importers, local government, government extension agents, and private extension agents. An estimated number of each of these stakeholders, per region, was also provided. Gender was considered within each of the stakeholder groups.

International and national stakeholder identification

Understanding the institutions that provide seed material and research outputs to potato producers and organizations in Georgia is an essential component of understanding the Georgian potato value chain and its relationship to global potato production. To better understand the institutions involved, participants were asked to identify major national and international stakeholders from both public and private sectors that were involved during the last year in potato and information exchange with producers in Georgia. National institutions were defined

as public or private agencies that work across boundaries of the regions in the country. Participants could discuss this prior to providing their answers on the survey instrument.

Seed sources and harvest uses

Experts were asked to identify the main sources of seeds for each region. This was also done for seed multipliers and seed traders. Experts were then asked to identify how the harvest was used in different regions and also for small- and large-holder farmers. The latter also helped understand seed sources and flows as a part of the potato harvest is often saved for seed.

Variety release and adoption

We collected two databases, one on release and one on adoption. The release database comprises of a list of released, imported, and local varieties. This database served as the basis for the adoption database which includes detailed estimations for each released variety was established during a one-day workshop. In collaboration with our local partners we first established a list of experts and potential participants. Invited experts were retired or still working in the potato value chain as breeders, extension agents, crop management specialists, seed traders, and private sector officials. Special attention was also placed on inviting female experts to create a great diversity of participants.

After experts identified three major production zones, we validated the list of potato varieties against the expert opinion. To do so, we invited experts to individually write down on sticky notes according to their knowledge the names of varieties currently cultivated. We then presented the results on a wall and discussed these in the entire group. After that, the entire group was split into two groups based on prior discussion on major production areas. Given the relatively small area of potatoes in Georgia, it was agreed upon that both groups would estimate varietal adoption for all three regions. In case of difference in opinion between the groups, another plenary discussion would help identifying a full group consensus. However, the sub-group work started with individual expert adoption estimations in which we invited experts to give estimations for all production areas and seasons. For this purpose, we handed out a standardized form – we call instrument (see Appendix). We ensured, to the extent possible, that communication among participants was kept at a minimum during this individual exercise. These individual opinions formed the basis for the group discussions and estimations. These were established by discussing individual estimates. Here, it was important to ensure the participation of all group members.

Pest and disease risk assessment

Participants were initially asked to identify the five most economically important diseases and pests to Georgian potato production. These questions were not only informative, but also served to “warm-up” the group discussion. Experts were then asked to identify the remainder of the important diseases for Georgian potato production and estimate annual yield losses, frequency of occurrence, and available control mechanisms for each. Participants were able to discuss and debate.

Considering the top ten diseases, as defined by the previous discussion, the group was then given blank maps of Georgia with only the boundaries of the major administrative regions designated to identify 1) regions where the disease is consistently severe and causes substantial yield loss, 2) regions where the disease is occasionally severe and, 3) regions where the disease has been found. Each category was assigned a score (1-3, respectively), and the cumulative score for each district was summed and presented as a Cumulative Disease Index for each administrative region of the country. For this exercise, participants were asked to consider the last five seasons to account for atypical seasons and capture the environmental and temporal variability that is inherent to plant diseases.

Results

Major production regions

Based on input from experts, Georgia was divided into three main agro-ecological zones that are important for potato cultivation. These were the Northern Highlands, the Midlands, and the Southern Highlands (Figure 1). Even though the Northern and Southern zones are both highlands, the experts stressed that these differ considerably in terms of ambient humidity, temperature, soil quality, disease pressure, and potato varietal use. However, in both mountainous areas, planting and harvesting occur in mid-May and mid-October, respectively. In the midlands, potato is planted is in April and the harvest takes place from late August through early September. The total area planted to potatoes in Georgia was estimated to be 25,000 ha in the cropping season of 2016/17, although with large regional differences. The largest share (15,000 ha) of the area can be found in the Southern Highlands. In the Northern Highlands only 5% (or 1250 ha) of the total area is planted to potatoes. In the Midlands, the remaining 35% (or 8750 ha) can be found.

Local stakeholders

Overall, 19,023 local actors were identified, across regions, with 17,750 being farmers. Of the farmers identified (which should capture a majority of farmers from the 2017 growing season) 97% were identified to be smallholder farmers (Table 1). The experts identified that there were striking differences in quantities and stakeholder types across region. Broadly, the mountainous northern highlands districts have the smallest amount of potato production in the country and 100% of farmers (n = 650) in this region have farms smaller than 1.25ha. The southern highlands region is the largest in terms of harvested acres and number of actors, with an estimated 12,100 farmers, most (99.2%) which are smallholder. The midlands region has an intermediate number of farmers, between the north and south.

National and international stakeholders

Results indicate that importations of seed potato originate from a handful of private sector companies headquartered in Germany or the Netherlands (Table 2). International public institutions, such as CIP and USAID, may act as sources of new germplasm for research, provide funding and/or collaborate on research and development projects. National level private

institutions were defined as institutions that work with potato producers across multiple regions in Georgia. The experts identified four major national private institutions, each serving as a seed distributor, obtaining seed from international companies and providing this seed along with other inputs such as chemicals to growers.

Seed sources and harvest uses

Seed sourcing in Georgia is affected by region as there is much greater use of imported seed in the south and midlands than in the north, where most seed is produced on-farm and the rest is sourced locally (Table 3). Based on this analysis all seed for the Midlands came from outside that region, presumably because of high seed degeneration. When experts were asked to consider uses of potato harvest by region and farm size, however (Figure 3), they responded that some seed is saved by farmers in the Midlands. Overall, this analysis demonstrated that uses of harvest were similar for both large and small farms. Respondents considered that there were no large farms in the Northern Highlands.

Traders in the Northern Highlands were said to be opportunistic, traveling informally to farms and collecting surplus or diseased harvest to try to sell for food or seed. This may be a difficult seed source to track. This region also has a higher proportion of output being kept for consumption and for seed for the next season (Figure 3), indicating the subsistence nature of production in this region .

Although the midlands region, unlike the Northern Highlands, has a large number of farmers, production output in this region is believed to be almost entirely for sale as table potato (Figure 2) due to very high disease pressure and likelihood of degeneration. Thus, the majority of farmers in the midlands must buy seed yearly and this comes either from local suppliers or is imported.

Unlike the other two regions, the Southern Highlands has dedicated seed producers that provide seed to the rest of the southern region, and also to the other two regions. Experts believed that this is currently the only direction that potato seed is currently moved (south to north). Movement of seed potato from the Southern Highlands to the Northern Highlands and Midlands is a potential source of pathogen spread. This region also has an estimated 20 grower cooperatives. These cooperatives are likely highly linked groups of growers and more studies should be conducted to learn about their cumulative influence on the production system.

An overall view of seed flow in the country shows a signficiant influx of seed from Europe through the specialized seed importers in the Southern Highlands (Figure 2). This seed is then distributed to farmers in that region, the Midlands and to a lesser extent the Northern Highlands. Local sources and self-saved seed play major roles, depending on farm size and region, with the vast majority of seed in the north coming from those two sources.

Variety release and adoption

In the 2017 cropping season, a total of 28 potato varieties were either released, adopted, or released and adopted (Table 4). The total area planted to potatoes in Georgia was estimated to be 25,000 ha in the cropping season of 2016/17, although with large regional differences (Table 4) .

The largest share (15,000 ha) of the area can be found in the Southern Highlands. In the Northern Highlands only 5% (or 1250 ha) of the total area is planted to potatoes. In the Midlands, the remaining 35% (or 8750 ha) can be found. Looking at adoption rates at the varietal level, a single variety - Jelli - covers 26% (or 6,500 ha) of the total area planted to potatoes. Jelli is especially dominant in the Southern Highlands (30%). In the Midlands and Northern Highlands, Jelli covers 250 ha and 750 ha, respectively (see Table 4). The varieties Morfana and Picasso are equally important covering both 12% (or 3,000 ha) of total potato area. Though these three main varieties can be found in all agro-ecological zones, less dominant varieties appear to be regionally specific or their cropping area is so small that they are clustered in 'others'.It is noteworthy that the five most important varieties cover 65% (or 16,250 ha) of the total area.

Disease risk assessment

The five most important diseases and potato in Georgia were described to be late blight (*Phytophthora infestans*), Rhizoctonia stem canker and black scurf (*Rhizoctonia solani*), early blight (*Alternaria solani*), common scab (Streptomyces spp.) and blackleg (*Pectobacterium spp* and *Dickeya dadanti*); the most important pests were Colorado Potato Beetle (*Lema daturaphila*), wireworm (*Elateridae*), mole cricket (*Neoscapteriscus spp*), potato aphids (multiple species), and potato tuber moth (*Phthorimaea operculella*). Of these, the foliar diseases, late blight and early blight, are believed to have the highest potential yield loss under highly favorable conditions (Table 5).

According to the experts who were interviewed, potato late blight is a severe problem anywhere that potato is grown in Georgia (Figure 4a). Potato Wart (*Synchytrium endobioticum*) was identified as a new and emerging concern for the country (Figure 4c). Currently, the disease has only been reported in the southwest region of the Southern Highlands, but spread to other regions is possible given that the pathogen is known to be transmitted on infected seeds. Potato cyst nematode also appears to be recently introduced, and is currently a localized problem (Figure 4e), but also has the potential to spread locally on seed potato. To the authors knowledge, potato cyst nematode has not been formally reported in Georgia. Each of these pathogens is highly problematic because of their ability to persist in soil for long periods of time. Of all the regions, it appears that Samtskhe Javakheti and Kvemo Kartli have the highest cumulative disease index (Figure 4h). This may indicate that cost for disease control or loss due to disease may be higher here than in other parts of the country, although more supporting data would be needed to confirm this hypothesis. The Northern Highlands region is considered to have overall lower disease pressure, making this a potential good choice for seed production. It is unclear if this result is real, or a product of lower sampling attention and overall production in this region. In the midlands region, disease is considered a chronic problem (particularly virus), making seed production here nearly impossible.

This report gives an overall view of the potato seed system in Georgia but many unknowns remain. For example it is not known exactly how much seed is imported each year from Europe, nor are all of the importers known. There is also unclarity about degree to which seed from Europe is multiplied before sale. The flow of seed via locally available traders is also poorly

defined. As in many informal systems, these traders get seed from a number of sources and then resell this seed of undefined origin and unknown quality.

These concerns are listed below as questions that will facilitate future research on the subject.

1. What amount of seed is imported each year from abroad.
2. Is this seed multiplied by importers before it is sold, if so how many times?
3. What is really meant by 'local' sources of seed for small and large-holder farmers? We assume this can be traders, markets, other farmers….
4. Yield loss estimates often seem exaggerated. This is a common problem in this type of exercise and requires some sort of standardization.
5. Farmer cooperatives exist in the Southern Highlands; what is their role.

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