New varieties with virus resistance identified as part of Integrated Seed Health strategy

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Figures

Tables

Acronyms and abbreviations

ARC	Apical Rooted Cutting
CGIAR	Global research partnership for a food secure future
CIP	Spanish acronym for the International Potato Center
CRP	CGIAR Research Program
DAS-ELISA	Double-Antibody Sandwich Enzyme-Linked ImmunoSorbent Assay
ISH	Integrated Seed Heatth
MEPA	Ministry of Environmental Protection and Agriculture of Georgia
PS	Positive Selection
RTB	CGIAR Research Program on Roots, Tubers and Bananas
PLRV	Potato Leafroll Virus
PVY	Potato Virus Y
SMF	Seed Model Farm
USAID	United States Agency for International Development

Glossary

Yield stability: A process of increasing the ability to adjust to local environmental conditions and maximizing the potential resource of variety resistance to diseases through clonal selection and agronomic practices so that the advanced potato varieties will ensure sustainable yielding capabilities of potato yields and increase potato farmers' income.

Executive summary

The integrated seed health (ISH) strategy is an innovative approach to manage PSD in low-income countries. It integrates three components of PSD management: (1) resistance in the plant to PSD pathogens such as viruses; (2) on-farm management practices, for example, positive selection (PS) whereby farmers identify healthy-looking plants as seed providers; and (3) strategic use of high-quality (e.g., certified) seed. The project builds on recent advances in ISH developed as part of the RTB CRP. The project aims to produce evidence and tools to guide efforts by the Georgian government to strengthen the potato seed system and the extensive value chain it sustains.

The overall goal of the study is to improve the livelihoods of Georgian farmers by increasing profitability and sustainability of their potato crops and to increase capacity of national players in the potato seed value chain. The specific objective of the study is to improve the quality of potato seed of farmers in Georgia – selection of new potato varieties with resistance to viruses identified and promoted as part of the ISH strategy.

The study has successfully implemented an integrated approach to potato seed health in Georgia. The major achievements include the following:

- Completion of a seed sector baseline study, including a peer-reviewed publication.
- Development of a draft national seed plan for use by Georgian authorities.
- Development of a roadmap for seed certification for Georgia; participation in the first certification of a significant amount of certified seed (22 t).
- Evaluation of best technologies for early generation multiplication of potato seed (studies still in process), in collaboration with other projects.
- Testing of 28 new potato genotypes for resistance to viruses causing degeneration.
- Development of training materials (four printed manuals and four digital E-learning materials) and farmer training for on-farm seed management, particularly PS. A total of 1,119 people has been trained. In addition, several trainings of trainers' sessions were held, particularly involving the MoA and the private sector.
- Introduction of on-farm storage technology.
- Training of a PhD student in potato growth modeling.
- Carrying out gender study and training in collaboration with other projects.
- Using new varieties and improved management techniques, participating farmers experienced an average of 35% increase in yields on 122 demo plots, some of which were funded by partners and other donors.
- A total of 136 farmers, 120 scientists and practitioners, and one PhD student trained on PS, viral symptoms identification, ISH strategies, and potato modeling.
- Completed the third year of field trials for testing virus resistance in 28 new potato genotypes and four existing potato varieties, and field trials for adaption of a potato growth model. Three of the 28 genotypes tested for virus resistance have been selected for release as varieties in Georgia and will be given Georgian names.
- Through inter-project collaboration, finalized a study on gender mainstreaming in the Georgian potato sector.
- Formally provided feedback to proposed seed legislation in Georgia. The feedback resulted in modifications in the proposed legislation.

Overview

An important aspect of promoting the use of virus resistance is educating all stakeholders in the potato seed value chain on the role of resistance in maintaining seed quality. To this end, the International Potato Center (CIP) has used several opportunities to provide a conceptual understanding of virus resistance in plants and to provide evidence of the positive effects of using resistant varieties for maintaining seed quality and yield in Georgia.

The present research is aimed at the evaluation of virus resistance and the level of degeneration. The field trials are being conducted on new potato breeding lines received from CIP. The potato plants will be tested in a laboratory for presence of PVY and PLRV viruses using DAS-ELISA. In that last year of the trial, yield will also be measured as an indicator of degeneration. Thus, the relationship between virus presence and yield can be established. In one replicate of the trial, virus spread is controlled with insecticides and aphid netting, thus allowing for the measurement of yield potential of the lines without virus infection. This work is being done at the Tsilkani pilot plot area (Mtskheta) of the agricultural scientific-research center and has already led to the identification of lines that appear to have very high levels of virus resistance and low degeneration rates. Note that in all workshops and training events, the concept of ISH is discussed or at least reviewed. ISH includes virus resistance in potato as one of its main components.

Objective

Three varieties introduced from CIP-Lima Peru, and registered in Georgia under local names ('Javakheturi', 'Meskhuri', and 'Meskhuri Tsiteli') as well as local commercial varieties 'Agria' and 'Marfona' have been planted in six smallholders' farms in all three project implementation regions, two farms per region. A total of 0.56 ha has been covered under CIP varieties using modern production techniques. The purpose of the plots is to demonstrate:

(1) seed potato quality/quantity improvement through positive selection—a part of integrated seed health—in the three locations with different soil-climatic conditions
(2) advantages of CIP varieties over local commercial varieties (all locations).

The CIP varieties consistently outyielded the commercial varieties, and positive selection resulted in a near doubling of the yield.

This work initiated early in the study with a workshop where information about the potato system in Georgia was elicited from local experts (second-year report). The data collected were used to make a specific analysis of risks related to certain diseases. The analysis was reported in a poster presented at the American Phytopathological Society and in a refereed journal article, which in the last year was submitted to Agricultural Systems and has now been accepted for publication. Data were also used to develop a national seed plan. Part of the interest in conducting the baseline activity was to gain useful information on gender-related issues in the potato system in Georgia. As reported in the second annual report and in the refereed journal article, survey questions were designed to address gender; there were special sessions focused on gender analysis. The poster and refereed publication mentioned above are examples of using modeling to develop scenarios of PSD, or at least to explore risk of seed-borne disease spread. In the full paper, crop connectivity modeling was also used. In addition, the team used a PSD model to explore how different factors, such as host resistance and efficiency of PS, contribute to seed degeneration (here). This was done in the context of a workshop (second-year report) in which participants used the model to explore different scenarios and thereby gain a greater mechanistic understanding of PSD and how it can be managed with ISH. One of the primary outputs of the study has been the publication of a draft national seed plan for potato based on ISH principles. Data from the baseline study and many external sources were used to develop a prototype that was presented to and modified with partners in workshops. Initial work in this area was reported previously, in which we described how the team and local collaborators developed a draft national seed plan for use by the agricultural authorities in Georgia. This document was published as a non-refereed document in CGSpace.

Methodology

Evaluate the role of seed quality and host resistance in the yield gap

The complexity of this activity includes use of a generalized PSD model, not parameterized specifically for Georgia; progress on quantifying levels of resistance to viruses in potato varieties used, or to be used in Georgia; and parameterization of a potato growth model for use in Georgia. In 2020 the virus field trials was implemented in spite of great difficulty imposed by lockdowns and other measures related to Covid-19 control. The experiment was completed successfully, although with some reduction in plot size, and is currently being analyzed, together with data from the first two seasons. Similarly, a third season of field work was done to improve parameterization of the APSIM potato growth model. Both experiments were supervised remotely by CIP for virus resistance and by BOKU for growth modeling, as in-person visits were not possible.

The study has overall had a good level of completion of objectives. There have been significant outputs in all the primary objectives, including a general seed plan and a refereed publication; a roadmap to seed certification; adaptation of a number of training materials to Georgian conditions and training of MEPA staff and training of trainers; and significant gains in the area of identifying and promoting potato varieties with resistance to viruses. One major positive output of the project has been the general greater understanding within the potato sector, particularly research actors, of the ISH concept.

Identify and promote the use of new varieties with resistance to viruses as part of the ISH strategy

The importance of virus resistance as a component of ISH of potato has been promoted in various ways in the project. The ISH concept has been presented and discussed in every formal meeting with stakeholders, except during 2020 when meetings were not held due to pandemic precautions. In year two of the project, the concept was demonstrated with the use of PSD modeling, whereby the effect of host resistance in reducing degeneration can be seen graphically. The concept will be discussed in further detail in any publications resulting from the experiments on the identification of resistance to viruses in experimental cultivars.

Evaluate and use virus resistance in commercial varieties currently grown and new candidate varieties introduced by CIP. This area of intervention has previously been reported as having three components

Evaluating virus resistance in the field

This trial involves the planting and evaluation of 28 new potato genotypes and four locally grown varieties as controls, to test the degree to which they degenerate over time due to virus diseases. This is done by maintaining some plants of each variety free (as free as possible) of virus infection so that each year healthy and degenerated seed can be compared. For putative virus-free plants, protective netting and insecticides were used to manage insects that vector the viruses. At the end of the study, some varieties should be planted in larger plots to measure the effects of degeneration on yield. This was planned for 2020 but was not possible due to constraints caused by pandemic measures. The team is currently making an effort to analyze the data for a final report, but a publication in a refereed journal will probably require another year of field trial.

Assessment of varieties in farmers' fields

In addition to the on-station experiment above, three varieties introduced to Georgia from CIP and known to have at least partial virus resistance were evaluated on farmers' fields (see third- year report). For the 2020 trials, the most promising new variety, 'Meskhuri Tsiteli', was multiplied on farmers' fields with the commercial variety 'Marfona'. Both of these varieties have relatively good resistance to potato virus Y, a major cause of seed degeneration. Overall, in 2020, 70 t of 'Marfona' seed and 53 t of 'Meskhuri Tsiteli' seed were produced (Table 1).

Table 1. Production of seed and ware potatoes of varieties 'Marfona' and 'Meskhuri Tsiteli' in the 2020 season

	Marfona (kg)		**Meskhuri Tsiteli (kg)**	
Municipality	**Seed**	**Ware**	**Seed**	**Ware**
Akhalkalaki (demo plot)	4,770	2,105	21,580	2,045
Akhalkalaki (demo plot)	4,840	8,080	5,255	7,935
Akhalkalaki (farmers)	27,535	6,815		
Akhaltsikhe (farmers)	15,655	3,055		
Kazbegi (demo plot + farmers)	12,165	14,040	15,130	19,215
Kazbegi (demo plot)	1,870	730		
Marneuli (demo plot)	8,235	3,830	11,670	2,315
Total	**70,300**	**36,550**	**53,635**	**31,510**

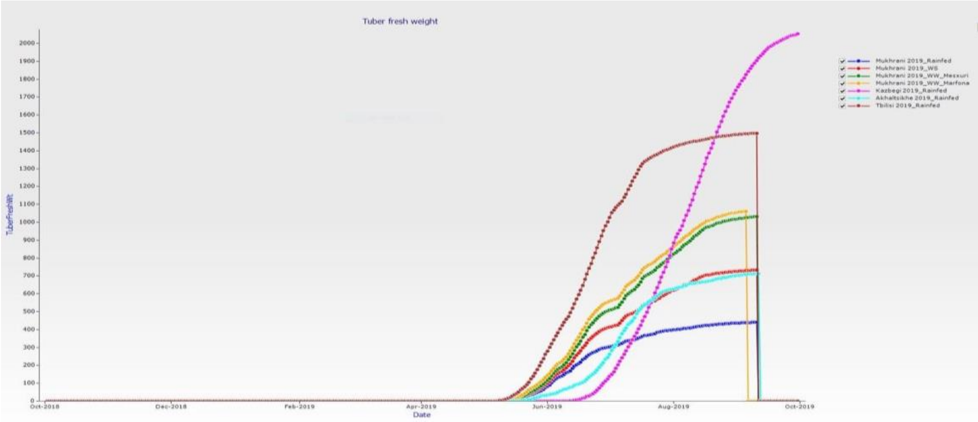
Modeling potato productivity

BOKU is involved in this project output (i.e., developing a potato simulation model for yield gap analysis in major potato-growing areas in Georgia). For the implementation of this task, Prof. Manschadi supervised a Georgian PhD student, Mr. Levani Tkemaladze, in collecting and analyzing detailed data sets on potato growth and yield formation for the purpose of parameterizing the APSIM cropping systems model (https://www.apsim.info) for Georgian conditions. For that, potato field experiments were conducted in 2018–2020 at the SRCA research station in Tsilkani under different irrigation treatments.

Time series of potato phenology, biomass and nitrogen accumulation, leaf canopy development, yield formation, and soil water and nitrogen dynamics were measured. These comprehensive data sets, together with additional data from other regions in Georgia, allowed for the first time the successful parameterization and evaluation of the APSIM-Potato model for climatic conditions and management practices in Georgia (Fig. 1).

In addition to supervision of the Georgian PhD student, Prof. Manschadi conducted a crop modeling training workshop in June 2018 for the scientific staff and students at SRCA and AgUni. The training was well received, given the novelty of this approach for agricultural research and development in Georgia. Figure 1. Screenshot of the user interface of APSIM with potato simulations for Georgia.

Figure 1. and evaluation of the APSIM-Potato model for climatic conditions and management practices in Georgia



The potato modeling work conducted for the first time in Georgia within the framework of this study has a huge potential for improving potato production in Georgia by conducting yield gap analysis for identification of major management constraints as well as for assessing future potato production in Georgia under changing climatic conditions. Given the similarities in climatic conditions and management practices for potato production between Georgia and its neighboring countries, the results of this project can also be extrapolated to those countries in future research and development projects.

The evaluation implied to identify the most advanced varieties for future testing in open field. In addition, the evaluation is being performed for 1,000 in vitro plants of pre-selected 12 CIP clones transplanted to a greenhouse in Akhaltsikhe to define profitability of varieties via an economic study of introduced modern technologies.

The final analyses will be completed for the next reporting period and published. This will be the basis for the private sector partners to decide on what technology is more suitable and beneficial for the business operation through SMF. Preliminary results showed that there is no production of certified seed in the country and potato farmers select and store small and non-marketable harvested potatoes to be used as seed potatoes. This is one of the reasons of low quality and yield of the produced potato locally. Certified seed is imported from several countries, mainly Germany and Netherlands, with a market price of €1 per kg (app. 3-4 GEL), that is not affordable for most potato farmers. Based on the analyses the innovative technology of apical rooted cutting (ARC) will provide farmers opportunity to buy locally high quality and high yield potato seed materials, which production price per seedling plant is approximately is 0.2 GEL (€ 0.04). The study will be finalized and published in next quarter.

Three CIP potato candidate varieties (396311.1, 309092.7, and 398208.620) that are resistant to viruses and other diseases have been selected, tested in three regions of Georgia (Kvemo Kartli, Mtskheta-Mtianeti, and Samtskhe-Javakheti), and documented (Appendix 1). The selected CIP potato varieties will be processed for registration and release in Sakpatenti in 2020. Microtubers' and apical cuttings' production potential, as well as yield was evaluated under greenhouse and open field conditions. In addition to selected three clones, other perspective clones have been selected via this study for future open field trials.

CIP continues PVS of advanced potato clones within USAID Potato Program in Georgia. Microtubers of 12 clones have been harvested, grown under greenhouse condition in Akhaltsikhe, Georgia. In separate trials in the same villages, CIP, together with its local partner, SRCA, and MEPA are evaluating 76 new candidate varieties introduced by CIP. For this purpose, the farmers were provided with the super-elite seed material and all plots were supplied with drip irrigation systems. The individual schemes of potato growing were elaborated and provided to the farmers.

Identify the most appropriate certification standards for Georgia, assessing consistency with international UNECE standards

This activity received a lot of input from the project. As reported in the third-year report, a workshop was organized in 2019 to begin the process of developing a roadmap to seed certification. A draft document was then circulated for comments and revised several times. The document was completed with input from many actors concerned with seed certification and presented to the Georgian agricultural authorities in 2020. In 2020 the project team also submitted a formal recommendation to Georgian authorities concerning a new seed law that would have mandated certification for all seed exchanges. The government has modified the law (Appendix 2) based on this recommendation.

In 2020 SRCA and project members participated in the first significant certification effort. Roughly 0.75 ha of seed was certified, producing 22 t of super elite seed of the virus-resistant variety 'Meskhuri Tsiteli'. This seed will be distributed to farmers for the 2021 season.

Identify best practices for field inspection adapted to proposed certification standards and assess consistency with UNECE standards for field inspection

The project has supported the MEPA in two areas for field inspection. In discussions in the 2020 workshop, field inspection was discussed and there was agreement to use UNECE field inspection documentation as a basis for modifying materials for use in Georgia. An important aspect of field inspection is the accurate identification of disease symptoms and other irregularities in the field. The project adapted training materials from previous work in Africa to assist field inspectors in identifying potato diseases in the field; these materials are supported by color images of disease symptoms.

Published outputs

- Full-length animated video on gender equality in potato production in English, Georgian, and Russian
- A shorter version of the animated film on gender equality in Georgian and in English
- An E-learning video stream on agriculture which has a large part on potato seed production on the channel Agro News channel
- The links to E-learning video on gender equality in potato production sector developed in three languages
- Refereed journal article, "An integrated seed health strategy and phytosanitary risk assessment: potato in the Republic of Georgia," submitted to Agricultural Systems and accepted for publication.

Trainings of farmers

Farmer training in the project focused on technical issues related to potato productivity and, in particular, production and maintenance of high-quality seed. More specifically, training has focused on PS and other on-farm seed management activities as well as general production activities such as irrigation and integrated pest management. As noted in Section 1.1, through a crosscutting activity involving USAID and the CGIAR Gender Platform, the project provided gender-equity training. Through its duration, the project trained 1,119 people in total.

In 2020 the project directly reached more than 772 participants (up to 50% women and 14% youth). The result came from the high percentage of female participation in training events held by the project. Apart from project-participating households, the numbers also include non-project participants on gender-training events held by the project for farmers of both sexes in all the three target municipalities.

During this reporting period, the project's 110 beneficiary farmers (18.2% women) were given high-quality potato tubers and seedlings with accompanying brief training by the agricultural expert on the special considerations for seed potato cultivation. All of the beneficiaries applied improved management practices or technologies in the framework of the ISH approach and integrated pest management, followed by additional individual training series. A total of 565 people was trained in these series.

Also during this reporting period, the project team, with the external consultant on gender issues and with the instructions and supervision of international expert, Nozomi Kawarazuka, trained 147 farmers in Akhaltsikhe, Akhalkalaki, and Marneuli on "Strengthening the Role of Women in the Field of Potato." The second cycle of training events for these three municipalities started in the second half of November 2020. During the training, and in close coordination with the Georgian Farmer Association, their representatives presented to the training attendees the GEOGAP standard and the Agroavti mobile application.

In the last part of the project, the team capitalized on newer media for training farmers and the general public. As indicated above, documents and animated videos were used to discuss the concept of ISH, PS, and gender. These videos were used for specific training events, but also were available to the public as television programs: an estimated 690,000 viewers and 1.5 million viewers watched the programs in Georgian and Russian, respectively.

Workshops and meetings

In 2020, owing to the COVID-19 pandemic, the project mostly relied on video conferencing for communications. In August 2020 CIP organized a workshop, "Possible Exceptions to Compulsory Certification of Seed Potatoes in Georgia." Local participants met at a hotel in Kazbegi; international participants attended via video conferencing. The participants discussed the new regulations for the production and distribution of potato seeds and the current certification system in Georgia. Experts from CIP (Greg Forbes and Jorge Andrade-Piedra) presented CIP's approaches to possible exceptions to mandatory certification of seed potatoes in Georgia. The deputy minister of the Ministry of Environmental Protection and Agriculture (MEPA) opened the event, summarizing overall seed certification in Georgia and the country's legislation efforts to synchronize with EU regulations. Some images available here (MEPA website).

The local participants capitalized on a seed certification event in Kazbegi to attend the opening of the CoolBot refrigerated storage facility in the village of Sno (see Section 2.2), thus exposing this innovative technology to a larger number of people involved in the potato sector.

The project held several meetings and awareness campaigns with private, state, and NGO institutions involved in the potato sector. As part of this effort, they were invited in December 2020 to the first "potato forum" in Georgia, which had been organized by the project. About 40 participants met via video conference to discuss ways to improve the Georgian potato sector. Consensus among various sector actors was developed for an enhanced market approach, such as the participatory market chain analysis, and for increased coordination and systematization of potato sector players. The deputy minister of MEPA, Iuri Nozadze, opened the event; USAID/Georgia Mission Director Peter Wilber delivered the welcoming speech; and Samarendu Mohanty, CIP's Asia director, gave CIP's welcoming remarks. During the event, speakers presented the best practices of using market opportunities and commercial innovations as key drivers in developing the potato sector in other countries. The representative from SRCA underscored the importance of high-quality seed potato production in the county as well as CIP's coordination in defining new markets in the potato sector. The Swiss Development Agency expressed interest in helping to develop both short vocational education training courses in seed potato production and relevant curricula to share with local Information and consultation centers under MEPA. CIP will lead the process, organizing and hosting quarterly follow-up meetings and defining activities for mutual implementation. There is interest in holding more potato fora in the future; the frequency and timing is to be.

Conclusions

All three selected advanced potato clones are a high -yielding potato breed, with an average of 6-10 tubers per plant. They generally large-shaped tubers with the deeply set potato eyes on tubers and oval-elongated, mostly similar shaped tubers. Average size of tubers for food production is 70-110 mm and weight are about-110-250 gr. Consumption quality of the breed is quite high. The dry matter of the inside layers is up to 18-22%, high content of vitamin C (88.83mg- 100g dry weight), culinary type. It has a good flavor and solid consistency. It is highly resistant to the following viral diseases: PVX, PVY, PVA, PVS. All three clones have a tall plant, has a strong stem and good coverage, violet colored flowers and small number of berries. It is moderately tolerant against mechanical damage and blue spots. It is distinguished by its drought tolerance, has a good tolerance against internal defects, well kept, characterized by a short resting period. Additional resistance to diseases shown by clones: “Aisi” and “Tskriala” have a high resistance to fungal disease -Phytophtora Infestant, “Kazbeguri” has a high resistance to Spongospora subterrane.

All three clones are characterized by a high ability to adjust to local environmental conditions, with stable yielding capabilities in Samtskhe-Javakheti and Mtskheta-Mtianeti Regions (30-40ton/hectare), high nutritional value and resistance to diseases.

Appendices

Appendix 1: CIP potato candidate varieties that are resistant to viruses and other diseases in three regions of Georgia (Kvemo Kartli, Mtskheta-Mtianeti, and Samtskhe-Javakheti)

1. Characterization of a new plant breed

Potato breed "Aisi" is obtained from the International Potato Center Gene Bank (Lima, Peru) with the clone number 396311.1 (parents (CIP391925.2 x C92.030)), which has been imported and tested in Georgia since 2016. " Aisi" is an average late variety with a dark red skin, and with a light yellow flesh. The tuber is oval- elongated, mostly similar shaped, thick-skinned. "Aisi" is a high -yielding potato breed, with an average of 8-9 tubers per plant. It is generally large-shaped tubers with the deeply set potato eyes on tubers. Average size of tubers for food production is 70-110 mm and weight are about- 130-250 gr. Consumption quality of the breed is quite high. The dry matter of the inside layers is up to 18-19%, high content of vitamin C (88.83mg- 100g dry weight), culinary type. It has a good flavor and solid consistency. It is highly resistant to the following viral diseases: PVX, PVY, PVA, PVS. "var Potato breed " Aisi " is a tall plant, has a strong stem and good coverage, violet colored flowers and small number of berries. It is moderately tolerant against mechanical damage and blue spots. It is distinguished by its drought tolerance, has a good tolerance against internal defects, well kept, characterized by a short resting period.

<u>Potato breed "Aisi" is characterized by a high ability to adjust to local environmental conditions, with stable yielding capabilities in Samtskhe-Javakheti and Mtskheta-Mtianeti Regions (35-40ton/hectare), high nutritional value and resistance to diseases.</u>

The breed characteristic:

#	Sign	Expression Quality		Index
		Aisi	Breed Standard "Desire"	
5.1	Light Sprout: Percentage of bluishness in annotated stem coloring	Medium	No existence or week	2
5.2	Plant: frequency of flowers	Medium	High	5
5.3	Crown of flowers: Annotated coloring of inner layers	Medium	Extremely week	5
5.4	Crown of flowers: Bluishness in annotated stem coloring	Medium	Medium	1
5.5	Ripening Time	Medium/Late	Medium/late	7
5.6	Tuber Shape	Oval-elongated	Oval	4

5.7	Tuber: Skin coloring	Red	Red	3
5.8	Tuber: Bud stem coloring	Red	Red	2
5.9	Tuber: Flesh color	Light yellow	Yellow	2

Similar breeds and differentiation from them

Name of Similar breeds	Signs, by which the above-mentioned breed is differ from the similar ones	Expression quality of signs	
		Similar breed	Candidate breed
Desired features	Frequency of flowering	High	Medium
	Time of ripening	Medium	Medium, late variety
	Tuber shape	Oval	Oval oblong

Immunoferment analysis

#	Viruses	Aisi	“Desire”	“Marabel”
1	PVY	R	M	R
2	PVS	R	M	R
3	PVA	R	M	M
4	PLRV	R	R	R
5	PVX	R	M	M

R - Resistant D-Durable
M -Medium Receiver
S - Strong Receiver

This breed “Aisi” has a high resistance to fungal disease of Phytophtora Infestant.

2. Characterization of a new plant breed: „Kazbeguri"

Potato breed "Kazbeguri" is obtained from the International Potato Center Gene Bank (Lima, Peru) with the clone number 309092.7 (parents (304347.6X304394.56)), which has been imported and tested in Georgia since 2016. Potato breed " Kazbeguri" is an average late variety beige skinned with pink spots. It is a high-yielding potato breed, with an average of 6-8 tubers per plant. It is generally large shaped with the deeply set potato eyes on tubers. Average size of tubers for food production is 70-110 mm and weight is about 120-230 gr. Tuber is oval-elongated, mostly similar shaped. Consumption quality of the breed is quite high. The dry matter of the inside layers is up to 18-19%, culinary type. It has a good flavor and solid consistency. "Kazbeguri"" is highly resistant to the following viral diseases: PVX, PVY, PVA, PVS.

Potato breed "Kazbeguri" is a tall plant, has a strong stem and good coverage, white flowers and small number of berries. It is moderately tolerant against mechanical damage and blue spots. It is distinguished by its drought tolerance, has a good tolerance against internal defects, well kept, characterized by a short resting period.

<u>Potato breed "Kazbeguri" is characterized by a high ability to adjust to local environmental conditions, with stable yielding capabilities in Samtskhe-Javakheti and Mtskheta-Mtianeti and Racha-Lechkhumi Regions (30-35ton/hectare), high nutritional value and resistance to diseases.</u>

The breed characteristic

#	Sign	Expression Quality		Index
		<u>Kazbeguri</u>	Breed Standard "Agria"	
5.1	Light sprout: Percentage of bluishness in annotated stem coloring	Medium	many	2
5.2	Plant: frequency of flowers	Medium	High	5
5.3	Crown of flowers: Annotated coloring of inner layers	Medium	Extremely high	5
5.4	Crown of flowers: Bluishness in annotated stem coloring	Medium	Medium	1
5.5	Plant: ripening time	average/late	Medium	7
5.6	Tuber: shape	elongated oval	Oval	4

5.7	Tuber: skin coloring	K beige	yellow	3
5.8	Tuber: bud tem coloring	pink	yellow	2
5.9	Tuber: flesh coloring	Pale yellow	yellow	2

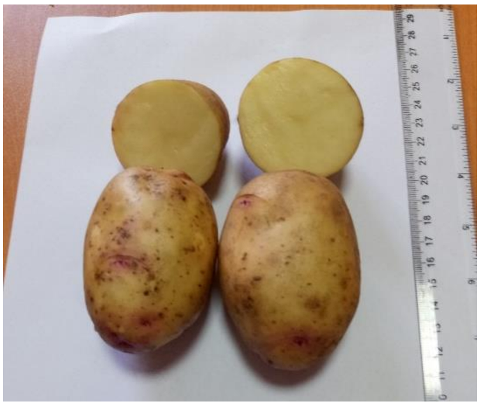
Similar breeds and differentiation from them

Name of similar breeds	Signs, by which the above-mentioned breed is differ from the similar ones	Expression quality of signs	
		Similar breed	Candidate breed
M Marfona	frequency of flowering	Medium	Medium
	ripening time	Medium	medium late
	tuber shape	Oval	oval oblong

Immune ferment analysis

#	viruses	Kazbeguri	Agria	Marabel
1	PVY	R	M	R
2	PVS	R	M	R
3	PVA	R	M	M
4	PLRV	R	R	R
5	PVX	R	M	M

R -Resistant; M -Medium Receiver; S -Strong Receiver.
This breed “’Kazbeguri ” has a high resistance to *Spongospora subterrane*

3. Characterization of a new plant breed:

Potato breed “Tskriala” is obtained from the International Potato Center Gene Bank (Lima, Peru) with the clone number 398208.620(parents (CIP393371.58 x CIP392633.64 population LBHT-1) , which has been imported and tested in Georgia since 2016. Potato breed “Tskriala” is an average late variety with a beige skin, is a high -yielding potato breed and 7-8 tubers per plant. It is generally large-shaped tubers with the deeply set potato eyes on tubers. Average size of tubers for food production is 70-110 mm and weight is about- 110-220 gr. Tuber is oval-elongated, mostly similar shaped, thick skinned. Consumption quality is quite high. The dry matter of the inside layers is up to 20-22%, culinary type. Has a good flavor and solid consistency. Potato breed “Tskriala” is a tall plant, has a strong stem and good coverage, white flowers and small number of berries. It is moderately tolerant against mechanical damage and blue spots.

“Tskriala” is highly resistant to the following viral diseases: PVX, PVY, PVA, PVS. “Tskriala” is distinguished by its drought tolerance, has a good tolerance against internal defects, well kept, characterized by a short resting period.
The breed “Tskriala” is characterized by a high ability to adjust to local environmental conditions, with stable yielding capabilities in Samtskhe-Javakheti and Mtkheta- Mtianeti (30-35 ton/hectare), high nutritional value and resistance to disease.

The breed characteristic

#	Sign	Expression Quality		Index
		Tskriala	Breed Standard	
5.1	Light Sprout: Percentage of bluishness in annotated stem	Medium	Many	3
5.2	Plant: frequency of flowering	Medium	High	5
5.3	Crown of flowers: Annotated coloring of inner layers	Medium	Quite strong	5

5.4	Crown of flowers: Bluishness in annotated stem	Medium	Medium	2
5.5	Plant: ripening time	Medium/Late	Medium	7
5.6	Tuber: shape	Elliptic	Roundish oval	3
5.7	Tuber: skin coloring	Yellow	Reticulum yellow	2
5.8	Tuber: bud stem coloring	Yellow	Yellow	2
5.9	Tuber: Flesh color	Pale yellow	Pale yellow	2

Similar breeds and differentiation from them

Name of Similar breeds	Signs, by which the above-mentioned breed is differ from the similar ones	Expression quality of signs	
		Similar breed	Candidate breed
M Marfona	Frequency of flowering	High	low
	Ripening time	Medium	Medium
	Tuber shape	Roundish- oval	Elliptic

Inmune terment analysis:

#	viruses	Tskriala	Marfona	Marabeli
1	PVY	R	M	R
2	PVS	R	M	R
3	PVA	R	M	M
4	PLRV	R	R	R
5	PVX	R	M	M

R - Resistant
M -Medium Receiver
S - Strong Receiver

The breed “Tskriala” has a high resistance to fungal disease of *Phytophthora infestans* .




Appendix 2: CIP's comments on the proposal for regulating potato seed certification in Georgia

31 July 2020

A number of countries have adopted seed laws that restrict or prohibit sale of uncertified seed (i.e., with verified and specified level of purity and phytosanitary health that is guaranteed by an independent agency, or has been authorized by a local or national government agency).

While this standard may seem to be a good proposition at first glance, there are several secondary issues that can make compulsory certification of potato seed problematic. For one, seed certification could drive increases in seed prices, which some farmers may not be able to afford. Mandatory seed certification may also restrict farmer access to certain varieties or landraces, reducing the diversity of potatoes being grown, and, in some cases, violating principles related to seed and food sovereignty and peasants' rights. Thus, there is a tension created between the desire to see all producers using certified seed and the on-the-ground reality of all producers being able to or desiring to use certified seed. These tensions are more extreme in low-income countries, where more than 90% of all potato seed is uncertified. This despite many of these countries having laws requiring that marketed seed be certified.

To overcome these obstacles, many countries have developed exceptions to strict certification requirements, which allow some actors within the potato production system to trade seed with few to no restrictions. In wealthier nations, these exemptions generally apply to very small portions of the potato sector, generally for private, noncommercial use; whereas in low-income countries they may apply to most farmers. Some of these exceptions are briefly described below. To avoid problems related to the strict mandatory seed certification for potatoes, the government of Georgia may wish to consider one or more of these exemptions.

Types of exemptions to mandatory potato seed certification

Seed price and access. Several options have been adopted to increase production and reduce seed prices, while maintaining quality. One method used has been the adoption of the denomination quality declared seed (QDS). This denomination was initially proposed by the United Nations Food and Agriculture Organization (FAO) and later adapted for potato and other vegetatively propagated crops by the FAO and CIP (Fajardo et al. 2010). The QDS approach is being used in Ethiopia (Gorfu et al. 2013; Schulz et al. 2013; Sharma et al. 2018), and some elements of it have been successfully applied in Ecuador (Kromann et al. 2016). Peru's Ministry of Agriculture (MINAGRI) can collaborate with the Georgian MoA to test and validate the QDS approach under Georgian conditions. The FAO outlines some of the key attributes of QDS (2006):

- A list of registered varieties eligible to be produced as QDS is established.
- Seed producers are required to register with an appropriate national authority.
- The national authority will check at least 10% of the seed crops in the fields that are registered.
- The national authority will check at least 10% of the seed offered for sale under the QDS designation.

Scale of production. A number of seed certification exemptions have been implemented for small-scale production of potatoes. In the United States, regulation of potato seed certification is determined at state level, and most states do not require that certified seed be grown on small amounts of land. For example, in Minnesota and North Dakota, fields less than 0.405 ha can be planted with standard seed (Robinson 2020). The same exemption exists in Colorado (Colorado Department of Agriculture–Plants 2018). While potatoes sold commercially must be certified, small private exchanges occur through garden clubs and other informal groups.

Types of market, variety, or landrace. In a number of cases, exceptions to compulsory seed certification have been implemented to allow for the exchange of seed varieties that have special value for maintaining biodiversity or that do not have commercial value (e.g., varieties that are useful for gardeners or small producers but do not interest commercial growers). Here are three examples of this kind of flexibility for seed certification standards:

- **European Union**. The European Council Directive 2002/56EC (2002) requires that all seed potatoes for sale must be certified. It appears this directive was used as the basis for drafting the new seed policy for Georgia. However, a subsequent European Council directive (2008/62/EC) issued two years later allows for the derogation of some types of potato seed, including conservation varieties and varieties of no commercial value, such as those referred to as “amateur” or “hobby” varieties. EU member states have flexibility in the implementation of this directive. For example, in the Netherlands requirements for registration and certification are relaxed for aforementioned types of seed, but quantities are limited in size and sale of seed must be local (Raad voor plantenrassen 2020).
- **Local varieties and landraces in Peru**. In Peru there is a non-statutory register of potato land races, and Peruvian seed law includes a number of classes to accommodate several seed types that are not certified, such as “declared seed” for which the quality is the responsibility of the producer. “Traditional seed” can also be legally sold without certification (Government of Peru 2018; Visser 2016).
- **Seed of small-scale farmers in Ethiopia**. Ethiopian regulations provides certification exemptions for (1) the use of farm-saved seed by any person and (2) the exchange or sale of farm-saved seed among smallholder farmers or agro-pastoralists” (Herpers et al. 2017).

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