

# Impact Coalition Hybrid True Potato Seed Scoping Report



The feasibility and desirability of an Impact Coalition on sustainable potato sector development implementing Hybrid True Potato Seed.

Report of a scoping study

Conducted by Netherlands Food Partnership

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## List of abbreviations

CIP	International Potato Center
CDPIT	Center for Development of the Potato Industry Tanzania
EKN	Embassy of the Kingdom of The Netherlands
HIP	Holland Innovative Potato
HTPS	Hybrid True Potato Seed
IIAM	Mozambique Agricultural Research Institute
KEPHIS	Kenya Plant Health Inspectorate Service
LMICs	Low- and Middle-Income Countries
MoAgri	Ministry of Agriculture, Nature and Food Quality
MoFA	Ministry of Foreign Affairs
NAO	Nederlandse Aardappel Organisatie/ Netherlands Potato Organisation
NFP	Netherlands Food Partnership
NPPO	National Plant Protection Organisation
PVP	Plant Variety Protection
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
VCU	Value for Cultivation and Use

Note: in this report the terms hybrid true potato seed or hybrid true seed refer to hybrid true potato seed. The terms seed potatoes, seed potato tubers or seed tubers refers to traditional seed potatoes (tubers).

# 1. Introduction

This report presents the findings of a scoping study on the feasibility of accelerating the implementation of Hybrid True Potato Seed (HTPS) in Low- and Middle-Income Countries (LMICs). This scoping study does not focus on the promises and challenges of the hybrid breeding technology, but rather on the broader system context of African agriculture and potato cultivation that is needed to sustainably introduce and scale Hybrid True Potato Seed. A starting point to build and support such an enabling systems context could be an impact coalition<sup>1</sup> that works on sector wide transformation. The aim of this scoping study is to explore the possibilities of setting up such an impact coalition.

The idea of undertaking a scoping study ascended after the [conference on 'The Future of Hybrid Potato'](#) that took place on 30 November 2020. Important players from the worldwide potato sector discussed the future of the hybrid potato and exchanged their experiences of implementing hybrid potato seed in a variety of settings. A few years ago one noticed a more wait-and-see attitude towards HTPS, but the discussions and the number of attendants (180) of the conference point towards an increased and widespread interest in the introduction and development of HTPS (in LMICs).

Solynta, a Dutch company that works on diploid hybrid potato breeding, approached the Netherlands Food Partnership (NFP) with the idea to conduct a scoping study to explore how the innovation of HTPS can be implemented sustainably using a potato sector development approach. HTPS can lead to less transmission of diseases and higher yields<sup>2</sup>, has significantly lower transport costs of tubers and an enhanced capacity to breed new hybrid potato varieties adapted to local conditions. NFP acknowledges this potential of HTPS to contribute to sustainable agriculture, food security and improved income for farmers, and as such to contribute to the Sustainable Development Goals. It is from this perspective that NFP has pledged support to take the innovation of HTPS further.

## 1.1 Objectives

The objective of this scoping study is to explore what is needed to build an impact coalition using a sector transformation approach to sustainably introduce and scale HTPS and identify which geographical focus would be best suited to start such an impact coalition. The following questions form the basis for the study:

- a. Why are an impact coalition and a sector development approach needed to sustainably introduce HTPS?
- b. What could be partners of an impact coalition on HTPS and what role could/should each partner play?
- c. What does an enabling environment for sustainable implementation of HTPS look like? What are hampering and supporting factors?
- d. What (public-private) funding instruments are available to support a coalition?

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<sup>1</sup> An impact coalition can be defined as a group of stakeholders intentionally working together and sharing information for the purpose of solving a complex problem.

<sup>2</sup> It remains paramount that clean starting material always gives more yield, whether it is true seed or seed potatoes. The increase in yield attributed to HTPS also applies to clean seed potatoes.

## 1.2 Approach of the scoping study

The Netherlands Food Partnership in collaboration with Solynta worked out a research framework for the scoping. The focus of the study is how to bring the innovation of HTPS a step further by forming an impact coalition. The role of Solynta during the study is to provide technical input and give feedback on the draft report(s) which may have led to some text being written more from a Solynta perspective even though many interviewees have given input (Annex I). The report becomes publicly available and NFP is open for feedback.

Two regions in Africa are chosen to focus on in this scoping study, being South-Eastern Africa (Zimbabwe, Mozambique, Zambia and Malawi) and Eastern Africa (Tanzania and Kenya). The reasons to focus on these regions and countries include:

- a. In these regions, potato is an important staple and/or food security crop (seventy percent of African potatoes are grown in East Africa). However, in all countries there are issues with seed tuber quality and its supply and prices are high. This means that most farmers are put into the position to save seed potatoes. In doing so the yield in general is very low and the level of diseases in the soil increases. HTPS could be a solution to these challenges.
- b. CIP varieties are in all the countries listed. However, the uptake of new CIP releases is slow. This is mainly because of the lack of infrastructure to produce seed tubers (or cuttings). The benefit of HTPS is that seed of new hybrids can be supplied in a timely way quickly and with limited to no seed diseases.
- c. Regulations for importation and registration of HTPS in these countries is not defined well (yet). Pioneering HTPS companies, like Solynta, are paving the way in these countries by discussing with regulators how best to manage this new technology. It differs per country how far this process is, but in all countries the technology of HTPS is introduced by demo trials.
- d. Regional dynamics have a strong impact on national potato sector developments and issues like variety registration and import of seed.

Though these regions are chosen to narrow the focus of the scoping, it is acknowledged that each country has its own unique context and brings its own challenges. These context specific challenges and opportunities per country will be addressed where possible.

The methodology of the study includes a basic literature review on the innovation of HTPS, the stage the innovation is in, and the challenges and opportunities that exist in introducing HTPS in LMICs. An overview of the literature consulted can be found in the footnotes. Primary data is collected through 22 interviews with stakeholders from the Dutch Potato sector, including representatives from the private sector, the government and research institutes.<sup>3</sup> The full list of interviewees can be found in Annex I. The set-up of the interviews is semi-structured and guiding questions used during the interviews can be found in Annex II.<sup>4</sup> It should be noted that this report is a first exploration. A next step could be a more in-depth scoping mission/study (by possible partners of an impact coalition) in one of the focus countries to gain a deeper understanding of the local context and local partners. Consultation of possible local and international partners and stakeholders should be part of such a follow up study.

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<sup>3</sup> NGOs working on potato sector development were approached, but we did not get a response on multiple requests for an interview.

<sup>4</sup> Detailed interview notes were made of each interview. These notes are available upon request, on the condition that approval is given by the interviewee.

## 2. The innovation

Potatoes are increasingly considered as an important crop in Eastern-Africa. East African potato cropping is mainly characterized by an informal seed system dominated by small-scale farmers. African farmers mostly rely on traditional low productivity varieties with a high rate of disease transmission. Most farmers grow less than 2.5 hectares and produce less than 10 t/ha. The varieties they use are adapted to the East African climate and soil conditions and farmers have experience with growing them. Mostly, no distinction or selection is made of tubers for consumption, propagation and distribution. Commercial growing of potatoes for processed products is limited: there are hardly potato processing facilities in East Africa.

As an alternative to conventional breeding and tuber propagation, (hybrid) true potato seed systems are currently being developed<sup>5</sup>. These systems do not only lead to less transmission of diseases<sup>6</sup> and higher yields<sup>7</sup>, but they also imply significantly lower transport costs of tubers, and an enhanced and accelerated capacity to breed new hybrid potato varieties adapted to local conditions that may contribute to food security aims in Africa<sup>8</sup>.

The current seed potato system is based on selected starting material or tissue cultures in which seed potatoes are propagated in subsequent years and are finally used as ware potatoes. The hybrid potato makes completely different systems possible of potato seed reproduction and cultivation. An (H)TPS-based system starts with true seeds that can be sown directly in the field or in specialized nursery systems. In both cases, the first harvest can supply ware potatoes or tubers that can be used as seed potatoes in successive years. Furthermore, it is theoretically possible to develop seed-based production systems comparable to the vegetable sector. Because the agronomic conditions of the HTPS cultivation systems are very different from those in the conventional seed potato systems, as young seed plants are vulnerable to sowing conditions such as frost and drought, HTPS cropping systems will not only require more experiments to identify the critical factors, but also specially trained growers and a supportive institutional context<sup>9</sup>.

### 2.1 The complexity of potato reproduction and breeding

The potato sector has different systems of breeding and multiplication. Fully understanding the various systems require expert knowledge on genetics. To comprehend the potential and challenges of (H)TPS one must understand to some extent these different systems, which are presented in the textbox and Table 1 in a 'simplified' way. Annex III offers a more in-depth explanation and provides a clarification of the undoubtedly debatable qualifications in Table 1.

<sup>5</sup> HTPS is not the first attempt to introduce true potato seed (TPS) in agricultural practices. There is a long-standing experience with TPS-systems, especially in mountain areas where transport is difficult. However, until now these systems have not been successful. There were many reasons why TPS did not work, but most importantly its quality did not match seed potatoes. Therefore it was only attractive to farmers in a 'niche' region like Nepal with limited access to seed potatoes.

<sup>6</sup> Potato tubers may be infected with over 200 pathogens, while only five viruses and one viroid are seed transmissible. If the hybrid seeds are produced in protected environments (greenhouses) with strict phytosanitary regulations, true seeds are devoid of any pathogen. This is similar to vegetable hybrid seeds, where strict certification rules are applied (GSPP), that enable transport of such clean seeds over the globe.

<sup>7</sup> It remains paramount that clean starting material always gives more yield, whether it is true seed or seed potatoes. The increase in yield attributed to HTPS also applies to clean seed potatoes.

<sup>8</sup> Jac. A.A. Swart & Dirk Stermerding (2019). Report of the workshop 'Opportunities and challenges for hybrid potatoes in East Africa', held on June 13-14, 2019, Ghent, Belgium. The full workshop report can be found on

<https://www.nfoodpartnership.com/insights/report-of-conference-potato-futures-impact-of-hybrid-varieties/>

<sup>9</sup> See also Exploring the Potential of Hybrid Potato Cultivars in East Africa

<https://knowledge4food.net/wp-content/uploads/2017/02/161130-Report-Solvnta-mission-to-East-Africa.pdf>

## Potato breeding and multiplication systems

### *Multiplication systems*

Traditionally, cultivated potato is reproduced **vegetatively**: parts of the plants are used as starting material to cultivate the crop. These can be tubers, mini-tubers or cuttings.

The alternative is **generative** propagation: true seeds are produced from the berries of the potato plant and used as starting material. This is defined as **True Potato Seed (TPS)**. TPS is the relatively easy, fast and efficient way to produce large quantities of seeds.

### *Breeding systems*

The vegetatively multiplication starts with (generatively) crossing two parents. The progeny is sown and vegetatively propagated over five to ten years under constant evaluations of important traits, finally resulting in a stock of some hundreds of tubers of the same genotype, that is registered as a new cultivar.

Two discrete breeding systems are to be distinguished: open pollinated breeding and hybrid breeding.

- If left to spontaneous set berries (**open pollinated**) the result is a mixture of op selfed seed and seed obtained after outcrossing. TPS produced in this way is genetically very diverse.
- If the fertilization is done manually one can make specific crossings of superior individual plants (**hybrid seeds**), which results in genetically more homogenous plants.

However, due to the very heterozygote character of the potato plant, the seeds still show too much genetic variation and farmers prefer a more uniform crop.

### *Improved hybrid breeding*

To generate homozygous parents and hybrid seeds many generations of inbreeding need to be applied. **Haploid potato** has twelve chromosomes, and each chromosome carries some 2,500 genes. **Diploid** plants have two sets of 12 chromosomes and **tetraploid** plants have four sets. The generation of homozygous parents is much faster at the diploid level than at the tetraploid level. The introduction of a gene for self-compatibility from a wild related diploid species into diploid potato (which is normally self-incompatible), made the development of homozygous inbred parents possible. After solving other breeding bottlenecks, hybrids were generated by crossing two inbred parents that showed similar yields as tetraploid cultivars. These (diploid) hybrids also make it possible to introduce new genes in only a few years. This system is defined as **Highly inbred potato (HIP)**.

A different approach is to apply a limited number of inbreeding generations at the tetraploid level. This system increases the homozygosity and a higher level of uniformity of the plants, but not at the level of hybrids generated by diploid highly inbred diploid parents. This system is defined as **Slightly inbred potato (SIP)**.

Next to the above-described methods for improved hybrid breeding, other methods for True Potato Seeds are being developed.

Of course, the seed potatoes produced by any generative breeding system can be used for vegetative multiplication (tubers, mini tubers and cuttings)

**Table 1: Summary of the main characters of the different systems (Ref: Annex III)**

	Vegetative system	Generative system	
	(breeding vegetatively propagated potatoes)	TPS (including SIP)	HTPS (HIP)
<b>Ploidy level</b>	Tetraploid	Tetraploid	Diploid
<b>MAB introduction one gene from a wild variety</b>	10 - 20 years	10 - 20 years	2 - 3 years
<b>MAB introduction two genes from a wild variety</b>	> 25 years	> 25 years	3-4 years
<b>Multiplication (commercial level)</b>	Tubers (5 - 10 years)	Seeds (one season)	Seeds (one season)
<b>Seed health</b>	Higher chance of contamination	Clean	Clean
<b>Uniformity</b>	Very high	Low	High
<b>Commercial interest</b>	Proven	Limited	Growing
<b>Conclusion</b>	Dominant system: Russet Burbank is leading cultivar for > 140 years	CIP introductions: mainly in developing world, area is declining	Potential: dynamic introductions of innovative products, value creation, disruptive change

Regarding the conclusion in Table 1, it must be said that historically the potato sector is characterized by **slow market acceptance of new varieties** and all systems will have to deal with this phenomenon. HTPS could change this if it succeeds to increase genetic uniformity and as such the added value of new varieties.

## 2.2 Stage of the innovation in LMICs

The Netherlands is the leading country in the development of HTPS. CIP started a research program on the development of True Potato Seed (TPS) in the eighties, but the research on Hybrid True Potato Seed (tetraploid and diploid) took off early 2000<sup>10</sup>. On the 16<sup>th</sup> of April 2017, Bejo Zaden received the first breeders' rights in the Netherlands on the seed-propagated F1-hybrid-potato variety 'Oliver' (N.N., 2017). However, the European organisation Community Plant Variety Office (CPVO) did not approve the registration. The Board of Appeal upheld the CPVO refusal decision and concluded that the variety was not sufficiently uniform subject to the features of its propagation.

Bejo Zaden was the first to get HTPS market access in Africa, in Kenya. Solynta was the first to start HTPS trials in Africa, in DRC, in 2016. In the same year Bejo started trials in east Africa.

Dutch breeding companies that are working on HTPS (Highly inbred potato) are Solynta, HZPC, and Aardevo, while Bejo Zaden is working on HTPS (Slightly inbred potato). These companies are in a similar process of the innovation: all are working on product development and the first introduction (and registration) of new varieties. Aardevo focusses on the Western/European market, whereas Solynta, Bejo Zaden and HZPC may also have a long-term focus on Western/European markets but at this moment they are exploring opportunities in LMICs. In some Eastern African countries all companies are present (like Kenya), in other Eastern-African countries only one or two companies are undertaking activities.

<sup>10</sup> Van Loon, J., 2019. Door eendrachtige samenwerking: De geschiedenis van de aardappelveredeling in Nederland, van hobby tot industrie (1888-2018). PhD thesis, Wageningen University. <https://edepot.wur.nl/469088>.

### Hybrid breeding and True Potato Seed

Hybrid True Potato Seed knows two aspects: the fact that it is based on diploid hybrid breeding and that it is a seed and not a tuber. These two aspects know their own challenges.

The biggest (technical) challenge for the hybrid breeding companies is to establish a sound genetic platform as the basis for a diploid hybrid breeding programme. To develop, establish and implement this genetic platform requires large investments in various scientific research fields like molecular, Mendelian and quantitative genetics. Once this system is mature, it is expected that a continuous pipeline of new products with added value will be developed, tested and the best adapted hybrid cultivars will be screened in Africa together with farmers in demonstration plots to select the best hybrid cultivars and the optimal cultivation systems.

Next to the breeding technology, there is the challenge of the implementation of the hybrid seeds as True Potato Seeds as starting material for the potato food systems in Africa. Here, the transformation of the current potato systems (using tubers as starting material) to hybrid potato systems (using true seeds as starting material) is the main challenge. The latter is the scope of this report. Hence, for the aim of this document, when using the term Hybrid True Potato Seed we do not focus on the breeding technology but on the true seed aspect.

The activities that are taking place around HTPS in LMICs vary per country: in some countries varieties are still being tested or in early stages of the registration process, in other countries one or more varieties are (almost) registered. The true seed potato systems also vary per context: sometimes local distributors are used to supply the true seeds, some companies choose to invest in larger local farms that have experience in potato cultivation, and yet others choose to capacitate local seed companies that have nurseries (which have experience in other horticultural hybrid crops) to cultivate the seeds. Especially Solynta and Bejo Zaden are looking at opportunities and business models that could provide smallholder farmers with (H)TPSs every season.

It is fair to say that the innovation is currently in a stage of finalizing the registration for a selection of varieties with a planned product introduction in one/two years in a few East African countries. Being at this stage it is important to look at the wider sector, system and context and what is needed for a sustainable introduction. As such one needs to look at innovations as packages, thus asking what the component of a hybrid seed innovation package would be and how to deal with context specificities and bottlenecks in ways that smallholders can benefit.

90% of interviewees share the view that HTPS is an innovation that can exist alongside other (more traditional) potato seed and cultivation practices and systems as the market for potatoes is large enough and preferred seed and seed systems are context dependent. There is more debate about the mid-term/long-term perspective. Half of the interviewees believes eventually the shift will be made towards the use of HTPS only, but this will take a long transition process (40-50 years). Predictions about when small-scale farmers can access HPTS at a large scale in multiple countries vary between two and ten years.

## 2.3 Opportunities and binding constraints

The opportunities and challenges for hybrid potato breeding and cultivation in East-Africa were discussed during a workshop 'Opportunities and challenges for hybrid potatoes in East Africa', held on June 13-14, 2019 in Ghent, Belgium<sup>11</sup> and during the conference 'Potato Futures: impact of hybrid varieties' held on November 30, 2020 in Doorn, the Netherlands. A summary of the opportunities and binding constraints for HTPS breeding and cultivation are shared here.

The opportunities of hybrid potato may contribute to the reduction of disease transmission, will make the storage and transport of propagation material (seeds) much easier, and may also accelerate the introduction of new potato varieties and traits. Therefore, hybrid potato can potentially contribute to food security and sustainability in the African context. Hybrid potato may also contribute to the development of commercial potato value chains in Africa, involving seed breeding companies, a formal system of certification and quality control, a specialized seed (tuber) propagation system and marketing of processed consumer products. Thanks to hybrid potato, the cultivation of potatoes might take on the character of vegetable cultivation in which cropping and products show much more variation and may better meet consumer preferences in more diverse ways.

Important challenges include limited access of farmers to credit for buying seeds and other inputs, not well-functioning certification agencies, extension services, practices of variety protection, and a lack of collaboration between stakeholders. Main challenges for this innovation are its acceptance by farmers, the creation of proper regulation for seed transport and distribution channels, the setting up of local tuber systems, its competitiveness in terms of productivity, the ability to breed varieties with new traits, and last but not least, the need for protection of breeders' rights.<sup>12</sup> Variety protection can be based on the UPOV and/or patent systems.

A generally recognized challenge (which is also mentioned by a majority of the interviewees) in Africa is that current regulations do not fit to true potato seeds (conventional or hybrid), which means that import and export of potato seeds are often not (yet) possible. Most African systems of regulation and policy making lack directives for the registration, import and export of hybrid true potato seed.

For a widespread scaling of hybrid potato seed one of the biggest bottlenecks is the intermediate infrastructure that you need including a network of nurseries with the capacity to raise plantlets from seeds, and competent producers of first-generation tubers. The development of cropping systems that fit to sowing and nursery conditions of hybrid seeds is a strong hurdle, especially given African climate conditions (e.g. temperature, water). Cultural aspects and tradition may also influence the acceptance of potato cultivation, based on TPS of hybrid cultivars.

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<sup>11</sup> Jac. A.A. Swart & Dirk Stermerding (2019). Report of the workshop 'Opportunities and challenges for hybrid potatoes in East Africa' and Jac. A.A. Swart, Dirk Stermerding, Pim Lindhout and Judith Jacobs. Report of the workshop 'Potato Futures: impact of hybrid varieties'. Both workshop report can be found on <https://www.nlfoodpartnership.com/insights/report-of-conference-potato-futures-impact-of-hybrid-varieties/>

<sup>12</sup> The chance of variety protection by patents, like is done in US, is not very likely to happen in the African context. The power of the innovation is the continuous launching of new hybrids with added value. These hybrids are protected by breeders' rights.

## 3. Scoping study results – a bird's eye view

### 3.1. A sector transformation approach

In a recently published review, authors from the field of root, tuber and banana crops take stock of the experiences with seed interventions in this field, based on a large variety of cases.<sup>13</sup> As the authors point out, efforts to learn from the experiences of the interventions seem to be meagre, resulting in 'blind introduction', based on the assumption that, once suitable varieties are available and seed prices affordable, farmers learn over time that investing in quality seed is worthwhile. This review again makes clear that this assumption is not supported by empirical evidence and that there is a real need for seed system interventions to take seriously into account the complex socio-economic and agro-ecological context in which they are operating.

In the African context, HTPS must be regarded as a very complex technological and organisational innovation, raising a lot of questions about how it fits into various formal and informal potato cultivation and distribution systems, the governance systems and extension services needed to deal with HTPS systems, the (financial) incentives and risks for seed and ware growers, and the potential role of NGOs, seed distributors and farmers' cooperatives in supporting this innovation. HTPS is a system innovation which may affect almost every step in the potato value chain. It can thus be seen as a disruptive and game changing technology, involving and affecting all players in the sector. Therefore, for HTPS to be successfully implemented, concerted action by many stakeholders on multiple fronts is needed to realise this transformation.

Whereas the specific topics, strategic innovation pathways and potato sector stakeholders will differ per country, action areas of a sector transformation approach can be organized in six interlinked key components<sup>14</sup>:

- A. Support the development and operationalization of a conducive enabling environment, which includes private-sector development, phytosanitary regulations, variety release, plant variety protection, seed import, agricultural finance and agricultural advisory and extension services; this also considers the political environment.
- B. Establish and support a potato sector platform that will foster linkages between, and coordination among, stakeholders in the potato value chains, while also promoting diversification in potato value chains/products.
- C. Support the potato seed sector, ensuring that farmers gain access to quality seed potatoes of modern varieties, allowing them to increase productivity; this should acknowledge the relevance and complementarity of different seed systems, while also promoting those seed systems that match the local context and opportunities.
- D. Strengthen the capacity of potato producers to enhance their productivity through use of quality seed potatoes of modern varieties and advanced cultivation practices, and foster

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<sup>13</sup> Almekinders, C.J.M. et al. (2019) Why interventions in the seed systems of root, tuber and banana crops do not reach their full potential, Food Security 11: 23-42.

<sup>14</sup> Deducted from 'Position Paper -Potato: contributing to food and nutrition security and stimulating employment and entrepreneurship through productive and sustainable climate-smart small-scale agriculture. June 2021.  
[https://www.nlfoodpartnership.com/impact\\_coalitions/potato-sector-development/](https://www.nlfoodpartnership.com/impact_coalitions/potato-sector-development/)

market linkages; practices need to be environmentally sustainable and economically feasible; a productivity increase at farm level is a requirement for sector transformation.

- E. Build and strengthen the capacity of relevant stakeholders in the private and public sector to support the development of the potato value chains.
- F. Measure the impact on the production, productivity and income of small-scale potato producers on a year-to-year basis, in a larger framework, accompanied by a transformation dashboard. Measuring progress and impact will ensure that all relevant stakeholders remain dedicated to the goal and objectives, and if required can learn and adapt their strategies for progress, increasing the performance of the sector and reaching impact. In addition, such measurement services support local policy and development goals.

A majority of the interviewees agree that a sector transformation approach is needed to introduce innovations sustainably. One of the interviewees adds: "Dialogue and collaboration, involving the whole sector 'diamond', is crucial to see how to make the innovation fit and to create both 'push' and 'pull'". Future impact coalitions that work on the introduction and scaling of the HTPS technology in LMICs should consider these key components of a sector/system transformation approach. It is however important to consider the degree to which companies are willing to and can be involved in activities in the competitive space. This will be elaborated upon later in the report.

## 3.2 Enabling environment

Among the interviewees there is discussion about which elements of the enabling environment are most important when starting an impact coalition. Several of them say that you should start in countries where the potato sector is well developed, like Kenya and Tanzania, as you need the infrastructure and the skills at farm level. In these countries plant breeders' rights are also legislated which is another advantage when introducing a new technology and/or new varieties.

Other interviewees (3) actually advise not to start in these countries as the potato sector is disturbed by too much interference, (public) investments and different interests. There are too many different players, too many initiatives introduced and promoted, and local actors and organizations feel threatened and are afraid to lose their influence. These resource persons therefore advise to keep the introduction of (H)TPS small and involve the local private sector to ensure the right market dynamics as was done for example in Guatemala. When considering this aspect, Malawi or Zimbabwe could be interesting countries to consider.

It is often mentioned during the interviews to look at local varieties and consumer preferences against which hybrid varieties have to compete, with the option to introduce hybrid varieties first in countries and regions where tubers are relatively expensive and poorly accessible, and consumers have less marked quality preferences. In Mozambique for example, HTPS would need to compete with seed potato tubers from South-Africa. Another argument often mentioned is to choose the country with the best local partners and contacts. HZPC for example, believes the enabling environment to be better in Tanzania, but choose to start in Kenya as they had a partner that could manage the trials well. The infrastructure and experience of local actors with seed cultivation is another factor that was mentioned multiple times.

Table 2 summarizes the considerations regarding the enabling environment in the six focus countries that were mentioned by the interviewees<sup>15</sup>. What most interviewees agree upon is that a regional focus would be the best strategy: with regional seed treaties being developed, one should choose a country to get varieties registered and then export to neighbouring countries.

**Table 2: Considerations in the enabling environment**

Focus country	Considerations
Kenya	(Local) Government is well organized, potato sector and infrastructure are functioning and PVP laws are in place. However, borders are sometimes closed for seed potato tubers by the government to meet the interest of local seed potato growers. Difficulties encountered in flexibility to adjust laws to HTPS technology and having to deal with lot of vested interests.
Tanzania	Potato sector and infrastructure are functioning and PVP laws are in place. Government in Tanzania is perceived as being bureaucratic. Infrastructure and experience to cultivate (horticultural) seed in place.
Zimbabwe	Security and land rights remain an issue though there are security mechanisms in place for foreign investors. Another difficulty is the high need for foreign currency, which makes it hard to repatriate funds, but an auction system is improving this situation. Potato sector and infrastructure were well developed before land reforms. As the majority of potato producers are now small-scale farmers, one is forced to work to a large extent with them.
Malawi	High demand for affordable potato seed. Seed is mainly imported from South-Africa. Import of seed potatoes from other countries like NL more difficult and expensive as the country is land locked. This offers opportunities for HTPS.
Zambia	No data available
Mozambique	Large potato market and huge demand for quality seed potatoes. Need to compete with imported South-African potato seeds.

### National procedures for variety registration

Great challenges exist around getting permits for the import of hybrid potato seed and national procedures for variety registration. In general the registration process starts with the Value for Cultivation and Use Test (VCU test). This test should be applied for (on behalf of the Dutch company) by a local party that has a legally registered company (e.g. a distributor or retailer). One needs to apply at the secretariat of the National Variety Release Committee (often hosted by the Ministry of Agriculture). The application for the VCU test follows the national seed law and regulations. The new variety must have advantages over the existing varieties, either in better yields or better resistance to pests and diseases. If the application is approved, import of the seed variety is allowed for the VCU trials. These trials often take 2 to 3 seasons, depending on the country.

Even though most countries have (to some degree) regulation and processes around variety registration in place, for HTPS it is often not clear which process will be followed, that of seed potatoes or vegetable seeds (see table 3 for an overview of the procedures followed in the focus countries). One reason for this is the fact that the technology is new and local government officials need to get accustomed with it before they can make decisions or change laws or procedures. In a recent HTPS registration process for example, the plant protection division asks if the applicant could declare whether the seed was free from Late Blight though this is not applicable for TPS, only for seed potato tubers. And even the Dutch National Plant Protection Organisation (NPPO) gets confused when they have to issue a phytosanitary certificate for HTPS.<sup>16</sup>

<sup>15</sup> The input from the interviewees is not checked with other sources

<sup>16</sup> Experience during the trial with HTPS in Myanmar

This challenge is further troubled by the fact that there is not a ‘one window policy’: often one needs to deal with multiple national (and Dutch) departments or organizations during the registration process which rules and regulations are not always clear or aligned (e.g. the National Variety Release Department, the secretariat of this department hosted by the Ministry of Agriculture, Plant Protection Offices, national research institutes). The fact that awareness creation and dialogue is needed severely delays the registration process. One interviewee therefore suggested that an impact coalition should make one person with a legal background responsible for (the communication during) the registration process.

**Table 3: Variety registration process HTPS**

Focus country	Registration process
Kenya	First HTPS variety registration was based on HTPS registration process in South-Africa. Though first variety is registered, this does not mean the process is now clear. Next applications might need to follow a different process.
Tanzania	Not clearly defined yet. Unsure how they will regulate.
Zimbabwe	There is a defined system for HTPS registration, but there has been no registration yet.
Malawi	Not clearly defined yet. It seems the authorities will follow the seed potato process.
Zambia	No data available
Mozambique	The government has a pathway to registration for TPS in place, but this has never been tested, because nobody applied for registration before.

Another challenging factor are the trials themselves. Not only can comparing HTPS to local varieties be a delicate matter due to interests involved, there is often also a limited influence on how the trials are organized resulting in biased results. This challenge also exists for variety registration for other crops, but it does delay the registration process. In practice, registration takes much longer than 2-3 seasons. All companies working on HTPS face these similar challenges in the variety registration process, that is why collaboration in this pre-competitive sphere is suggested multiple times during the interviews. Collaboration on this topic has happened in the EU context: Naktuinbouw then facilitated the registration of HTPS varieties in European countries. Chapter 5 on recommendations will make some suggestions on how to intensify pre-competitive and competitive collaboration.

The Ministry of Agriculture, Nature and Food Quality (MoAgri) is formally responsible for the registration and has delegated the implementation with Naktuinbouw. MoAgri has a department that supports (often together with NPPPO) in phytosanitary market access and a department that supports in plant breeders’ rights. It was also mentioned that agricultural counsellors of Dutch Embassies could play a role in using their contacts with local institutions. A few interviewees however mention that the Dutch attitude is perceived as ‘pedantic’ in some cases, so interventions need to be dealt with carefully.

### **Plant Breeders’ rights**

After a variety is registered, the (Dutch) company can start exporting seeds and sell through e.g. distributors. For the business model to be profitable, one needs intellectual property rights, which are in this context called plant breeders’ rights. A major challenge is the breaching of variety protection by farmers multiplying seed tubers that have been grown from hybrid seed. That is why Dutch companies are not willing to sell their elite varieties in countries which do not have (functional<sup>17</sup>) Plant Variety Protection (PVP) laws. Of the focus countries, only Kenya and Tanzania have functional PVP laws: in Malawi, and Zimbabwe these laws are not existing or not working properly (this needs yet to be checked for Mozambique and Zambia).

<sup>17</sup> In some countries, like Myanmar, there is a PVP law but it is not functional

Without denying the importance of plant breeders rights, it is argued for that research done with public funds should reflect the public good of affordable planting material. The price of hybrid seed is not yet known, but it is hoped that a 'high volume – low price' approach will lead to equitable access, thus contributing to SDG2.<sup>18</sup> It is like the Kenyan slogan "good seed costs nothing, it pays", whereby transport costs of hybrid true seed do not make the difference, but the research efforts that add value to the seed.

### **Sustainability: business models**

Plant breeders' rights is an important aspect for developing a profitable HTPS business model. Dutch potato seed and breeding companies that are not investing in HTPS question whether a profitable business and/or distribution model can be developed. One of the interviewees explains: "the context for scaling in LMICs is very challenging: huge changes in the enabling environment, in the sector and at the farmer level are needed that require large amounts of investments. And for an innovation that has not proven itself yet and with a market consisting of resource poor small-scale farmers, it is questionable who is willing to pay for these investments". Another interviewee adds: "HTPS has added value in areas where seed potatoes are expensive or not accessible. In these areas however there is no infrastructure, so you need to set up a whole value chain and that requires huge investments".

Related to the investments that are needed, the pricing of hybrid potato planting material is perceived as a key challenge in setting up a profitable business model. The price to the farmer will be determined by the genetics of the variety, the price of (true) seed production and the price of seed potato (tubers) production. Lower transportation costs will reduce the cost price of (H)TPS, though some argue that the transportation costs are only a small percentage of the seed potato price.

How much one can ask for the planting material – and which margins are feasible – depends on the added value in terms of quality and (economic) yield. Traditionally, the margins in potato are small, new varieties have relatively little added value and the service life of varieties is very long. This is different in vegetable breeding: rapid succession of new varieties, which are also purchased relatively quickly by horticulturalists, short lifespan of varieties, high prices and large margins. Hybrid potatoes could also lead to a shift from the traditional business model to the vegetable business model. However with potato production a farmer will compare the price of quality seed with the increase in yield and the vegetative reproduction option. That is why margins of potato seed remain low, around 15% as compared to horticultural seeds where margins are much higher. With low margins, high volumes are needed. Van Bruchem (Bejo Zaden) admits that a focus on cost pricing is all important but is also confident that Bejo will be able to offer seed at a price comparable to those common in Africa for open field vegetables like tomato and pepper, which prices are in their turn much lower than in greenhouse cultivation in the Netherlands.

Next to models that try to keep prices low, there are 'high price, high return on investment' models considered. These models are based on the idea that higher seed prices are the driver for high breeding investments leading to a fast development of better cultivars for the farmer. It is argued that these models are more sustainable, as keeping prices low will not stimulate breeding investments. Heleen Bos of Rijk Zwaan, who has experience with facilitating a paradigm shift from farm saved horticultural seed to hybrid varieties in the SEVIA project<sup>19</sup>, says it is possible to ask for a higher price, but then the added value, higher yields and a higher price in the market, should be shown to farmers. In this 7-year

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<sup>18</sup> Jac. A.A. Swart & Dirk Stermerding (2019). Report of the workshop 'Opportunities and challenges for hybrid potatoes in East Africa'

<sup>19</sup> <https://www.rijkszwaan.com/nl/mvo/ontwikkelingsprojecten>

project they invested heavily in demonstration and capacity building. They even calculated the return on investment together with the farmers. And interestingly enough they worked on this paradigm shift in close collaboration with East West Seed, one of their competitors. This collaboration was based on (pre-competitive) cultivation support (capacity building) and in the field of breeding, both companies had their own (competitive) programme.

The model of 'high price high return on investments' can be applied to crops that cannot be propagated vegetatively or as 'Farm Saved Seed'. However, this model encounters constraints in the potato sector since (H)TPS results in tubers and a grower can further propagate these tubers. So even in case of a very high yielding variety, the price of the (H)TPS cannot be too high, potato growers will propagate seed potatoes themselves and buy new seed every 5 years instead of every year.

The overall conclusion is that several business models are expected to be feasible, but within the sector there are differing opinions about the most realistic ones. Future will show which works best, both for individual parties and for the entire chain. The most sustainable models are based on a system that benefits all parties in the chain. Research on the economic feasibility is needed while implementing (H)TPS pilot projects.

### **Informal and formal seed systems**

It is recognized that variety development often does not focus on the specific needs of African potato systems as a whole.<sup>20</sup> The common intervention framework, aiming at the introduction of high-quality seeds in developing countries, strongly relies on the establishment of a formal seed system. However, as becomes clear from discussions in the literature, this strategy is controversial for its failure to address the needs of the many resource-poor smallholder farmers in Africa and other regions in the world. In response to this disconnection, 'participatory plant breeding' has been introduced and other system orientated strategies have been proposed, emphasizing the need for a diversified, pluriform seed system.

Clean true potato seed may indeed be an opportunity for smallholder farmers, but it will spread mainly through informal channels, as farmers will buy the seed and then multiply and sell seed potatoes (tubers) informally. Numerous observations covering 40 crops throughout the world show that around 90% of seeds comes from farmers' own and their neighbours' stock and from local markets, demonstrating the strong tradition of farmers. Seeds from this informal source are more readily available and affordable for smallholder farmers, though they may be less adapted to local conditions. They are also a source of local agrobiodiversity and have cultural meanings, representing biocultural heritages which may get eroded by the use and requirements of seeds from the formal system.

However, certified (hybrid) seeds are less vulnerable to diseases and more high yielding. Therefore it is important to consider how HTPS fits into various formal and informal cultivation and distribution systems. Links between both systems do exist already as formal systems use genetic resources from the informal system and, the other way around, varieties from the formal system diffuse into the informal one due to the need of farmers for more diversity. By strengthening the exchange of knowledge, materials and experiences between both systems, smallholder farmers may be empowered and can improve their livelihoods. This requires a policy environment aiming at a mutually reinforcing relationship between informal and formal seed systems, also reconciling farmers' and plant breeders' rights with respect to new (potato) varieties.

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<sup>20</sup> Peter Gildemacher (KIT) in Jac. A.A. Swart & Dirk Stermerding (2019). Report of the workshop 'Opportunities and challenges for hybrid potatoes in East Africa' and Jac. A.A. Swart, Dirk Stermerding, Pim Lindhout and Judith Jacobs.

The question here is: can you have a system that allows smallholder farmers to grow into emerging entrepreneurs with potatoes as a base crop? This is only possible with an efficient organization of the food chain as a whole. The challenge is to help farmers realize the potential of potatoes. As there is no blueprint miracle potato that fits everywhere, hybrid breeding as a new approach can help diversify the seed system to deal with the variation in conditions. A crucial issue from the economic point of view is how to breed potatoes that fit both small- and large-scale producers.

### 3.3 Stakeholder analysis

The transformation of the potato sector in a country requires actions in different areas, depending on the context of the country; the challenges, ambitions, strategic innovation pathways and partners to be involved for achieving the vision of the potato sector will differ per country. A potato sector roadmap can be considered as a strategic and policy document guiding stakeholders in improving the performance of the sector and serving as a reference for collaboration between the government, stakeholders and development partners<sup>21</sup>. This section will elaborate on which stakeholders need to be considered when forming an impact coalition, what their interest may be and what role they could or should play in the collaboration.<sup>22</sup> It is recognized that the list of possible stakeholders and organizations mentioned is not exhaustive: the overview is meant to give an initial overview of important actors to be considered when applying a sector transformation approach. When wanting to start an impact coalition in a specific country, a more detailed stakeholder analysis is needed taking the local demand and context into account.

#### 3.3.1 Partners at local, national and regional level

When asking interviewees about lessons learned of previous potato sector development programs, the majority states that local stakeholders are key in the success of a program. Their involvement should not be limited to being informed (about the technology) or being asked for support, but they need to be co-creators and implementers of the technology based on their needs, interests and objections. Local stakeholders must be involved in the design of the program and the assessments of the technology.

##### **At local level – farmers**

For a potato system transformation one needs to operate at multiple levels, requiring interventions both at the policy level and at the ground level.<sup>23</sup> During the interviews it was mentioned that the plant breeding process is often not specific enough. Especially with a game changing innovation, farmers need to be involved from the beginning to convince them of the benefits and to increase adoption rates. Farmers should be involved in testing pre-commercial hybrid cultivars, that have been preselected by breeders based on the product profiles defined by farmers.

One of the biggest bottlenecks for a widespread scaling of hybrid potato seed is the intermediate infrastructure that is required, including a network of nurseries with the capacity to raise plantlets (G0) from seeds, and competent producers of first-generation tubers (G1). By supporting farmers with technical know-how, they may become local seed producers and many farmers have already experience with growing hybrid peppers and tomatoes. The adjustments to the existing cropping

<sup>21</sup> Deducted from 'Position Paper - Potato: contributing to food and nutrition security and stimulating employment and entrepreneurship through productive and sustainable climate-smart small-scale agriculture. June 2021. [https://www.nfoodpartnership.com/impact\\_coalitions/potato-sector-development/](https://www.nfoodpartnership.com/impact_coalitions/potato-sector-development/)

<sup>22</sup> To identify potential partners for an impact coalition in a specific country or region a more in-depth stakeholder analysis is needed.

<sup>23</sup> Remark Mandla Nkomo (Solidaridad) in Jac. A.A. Swart, Dirk Stemerding, Pim Lindhout and Judith Jacobs. Report of the conference 'Potato Futures: impact of hybrid varieties'.

system and crop management handling due to true hybrid seeds as starting materials requires new technologies and skills e.g. seedling production, nursery management, plant density, and agronomic practices. A trial in Myanmar with HTPS showed that the required new skills of farmers are challenging. HTPS needs to be germinated in nurseries and that requires strict temperature control (<20 degrees Celsius during germination and higher after germination) and irrigation. After germination the plantlets need to be transplanted to the field, which also requires additional knowledge and skills of the farmer. If agricultural practices are not done properly, yields drop drastically. As farmers are used to work with seed tubers, it is important to clearly and timely inform potato farmers about the necessary changes in their farming practices when shifting from seed tubers to plantlets.

The trial in Myanmar furthermore showed that capacity building is challenging and does not happen overnight.<sup>24</sup> Dissemination of knowledge and materials c.q. reaching large numbers of small farmers is an enormous challenge and requires dedicated strategies. The authors of the report advise to start implementing the HTPS technology by finding local seed farms or companies that will grow the seeds into plantlets that are sold to farmers. In practice, this also happens: Bejo Zaden is using local seed companies that have experience in growing cabbage plantlets to grow plantlets from HTPS and HZPC is using larger farms they have already partnerships with to cultivate HTPS seed (to seed tubers). By having local seed companies as partners (Dutch) breeding companies can transfer the necessary knowledge and skills to these local partners that can grow the seed into plantlets (and seed tubers). It is even better and more efficient when these local seed producers have a presence in multiple countries, like for example SeedCo who has offices in Malawi, Zambia, Kenya and South-Africa.

One of the interviewees puts forward another argument to use local seed companies: for a small-scale farmer it is more profitable to produce ware potatoes than seed potatoes at the moment. This is confirmed by the results of a customer study that was done in Myanmar: 50% of the farmers wanted to buy seedlings grown from HTPS, 25% want to buy seed tubers, and 25% want to buy the HTPS seeds. In time it should be possible to involve farmers more in the cultivation process offering business opportunities (also for youth and women). An interviewee made a comparison with the rice production process in Asian countries: here farmers also need to grow the seeds in small nurseries and then transplant these to the field. It took some time to get farmers familiar with this process, but now the majority of rice farmers are the owners of the entire process.

Next to new competencies that are needed (and that need to be acquired), the return on investment is critically looked at by farmers, as well as by alle relevant partners in the potato value chain. With seed potatoes farmers can harvest after three months. When planting seedlings from HTPS it may take 3 to 4.5 months before they can harvest<sup>25</sup>. This means an additional investment of max. 1.5 months which should lead to at least double yields if it is to be economically interesting for small-scale farmers. For this challenge one can say 'seeing is believing': one should make farmers see the added value of hybrid quality seed through mutual learning in farmer field trials.<sup>26</sup>

Cultivation and the choice of crop varieties in Africa has also a cultural aspect, as they are rooted in local habits and based on the farmers' right to use their own seeds. These practices might be deeply rooted and farmers' perceptions and behaviours are difficult to change. This aspect is also highlighted by an interviewee who has a lot of experience in introducing seed innovations in horticulture: "a real culture and mindset shift is needed to switch from seed tubers to HTPS. Potato cultivation is often

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<sup>24</sup> Final report (PPT) Introducing True Potato Seed to Myanmar. Joep van den Broek, Rien van Bruchem, Charles Miller and Abishkar Subedi, December 2020

<sup>25</sup> Based on trial results in Myanmar

<sup>26</sup> Stated by Maaïke Groot from East West Seed in Jac. A.A. Swart, Dirk Stemerding, Pim Lindhout and Judith Jacobs. Report of the workshop 'Potato Futures: impact of hybrid varieties'.

deeply rooted in culture, so you need to change cultural practices, which is not so easy to do and should not be underestimated”.

Within the field of cultural aspects, gender can play a specific and major role because some crops, e.g. legumes, are considered as a ‘women’s crop’ as was found in Malawi. Research in Ethiopia showed the impact of family ties and social status on the distribution of improved seed potatoes through informal channels.<sup>27</sup>

### **At local level – local partners**

Next to the role of farmers, there are other local actors that need close involvement in successful sector transformation. It depends on the country, context and sector, but farmers organizations could play an important role in e.g. extension and capacity building, access to small-scale farmers (like for the selection of model farmers or trials), access to finance, and awareness creation. The Dutch not-for-profit agri-agency Agriterra<sup>28</sup> has a lot of experience in working with and capacity strengthening of farmers organizations, also in potato sectors in multiple LMICs.

Local NGOs (or international NGOs with foot on the ground) could play a similar role in capacity development (for example on good agricultural practices and financial literacy) and attitude change, but they often also work on topics like inclusiveness and gender issues. Local NGOs can also play a role in supporting access to markets, like contract farming. One of the interviewees mentioned that contract farming might be an interesting modality for HTPS in the beginning as the contracting party (or/in partnership with a local NGO) could provide the necessary extension services. Local NGOs can also help in arranging multi-stakeholder dialogues. Mandla Nkomo explained during the conference last November how Solidaridad in Mozambique has been helping the country to create an enabling seed policy environment by bringing all stakeholders around the table.

Local seed potato importers and distributors are another important actor as Dutch companies need a party that has a registered company in the country to apply for the Value for Cultivation and Use (VCU) trials. The seed potato import sector in LMICs is often characterized by a mixture of various actors from individuals, NGOs, small private companies and large seed companies.

As mentioned before, processing companies could play a role in access to markets or contract farming. However, in most LMICs the potato processing industry is not well developed (yet) and opportunities to involve processing companies as partners are hence limited. There are opportunities to include local potato value chain companies through a potato platform, like is the case in Tanzania with the Southern Agricultural Growth Corridor of Tanzania (SAGCOT) in the CDPIT project.

### **At national level – government and public (research) institutes**

All interviewees highlight that the local government should be supportive and willing to invest in the introduction of HTPS for it to be successfully introduced. Local governments work with policy documents on agricultural strategies and priority crops, which partly determines their interest or support to work on (innovations in) potato sector development. Table 4 gives an overview of the focus crops of the focus countries’ national governments<sup>29</sup>.

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<sup>27</sup> Almekinders, C.J.M. et al. (2019) Why interventions in the seed systems of root, tuber and banana crops do not reach their full potential, *Food Security* 11: 23-42.

<sup>28</sup> <https://www.agriterra.org/>

<sup>29</sup> This information is based on interviews with the Dutch embassies in these countries and are not triangulated with other sources.

**Table 4: Focus crops national government**

Focus country	Focus crops
Kenya	Increased interest in potato production.
Tanzania	Increased interest in potato production, but crop is not perceived as a potential cash crop.
Zimbabwe	Focus has been on maize and sorghum production, but ambition is to increase the production of potatoes in the future.
Malawi	Food security of high importance to the Malawian government. Climate change is affecting maize production through drought. That is why they are looking at alternatives: potatoes and sweet potatoes can function as a substitute
Zambia	No data available
Mozambique	Potato is one of the fifteen priority crops of the Ministry of Agriculture.

Next to the focus of the local government, it is of high importance to know the different values and (vested) interests of local stakeholders, especially those of public/governmental institutes that have a stake in potato sector development, e.g. registration and seed services, seed health and inspection services or agricultural research institutes (see table 5 for examples in the focus countries). Most governments have the ambition to produce seed locally and be less dependent on seed imports. Local agricultural research institutes might breed their own varieties and are not keen to increased competition. Institutes involved in registration, import and phytosanitary issues have their own interest and might not want to lose their influence. One of the interviewees mentioned that the positioning of HTPS should be dealt with carefully as there is a risk that the local government might move away abruptly from other options like importing seed potatoes, thereby not having food security as their main interest in the short run. Besides the existence of different interests, there is the challenge that is often not clear where the priorities of local institutes lie and what their responsibility is.

**Table 5: Public institutes responsible for registration and certification**

Country	Institute	Main responsibilities <sup>30</sup>
Kenya	Kenya Plant Health Inspectorate Service (KEPHIS)	<ul style="list-style-type: none"> <li>• The government parastatal responsible for assuring the quality of agricultural inputs</li> <li>• Plant Protection Service department responsible for phytosanitary services</li> <li>• Variety testing and release (NPT, DUS), Plant Variety protection (PBR), Seed Certification, Authorization of persons and trade facilitation.</li> <li>• Other support services include; coordination of seed industry, capacity building of staff and stakeholders and farmer advice.</li> </ul>
Tanzania	Tanzanian Official Seed Certification Institute (TOSCI)	<ul style="list-style-type: none"> <li>• Officially charged with all aspects of seed quality control and seed certification.</li> <li>• - Responsible for the National Performance Trials (NPT) of new varieties.</li> </ul>
Zimbabwe	The Seed Services Institute (SSI) under the Ministry of Agriculture	<ul style="list-style-type: none"> <li>• Regulates variety registration, seed production and marketing activities</li> </ul>

<sup>30</sup> The exact responsibilities and authority of these institutes are specified in the National Seed Act of these countries.

Malawi	The Seed Services Unit (SSU) of the Department of Agricultural Research Services (DARS)	<ul style="list-style-type: none"> <li>Responsible for quality control and certification.</li> </ul>
Zambia	Seed Control and Certification Institute (SCCI) - a government department under the Ministry of Agriculture and Livestock (MAL)	<ul style="list-style-type: none"> <li>Responsible for seed quality management and certification</li> </ul>
Mozambique	The Department of Seeds in the Ministry of Agriculture (MINAG)	<ul style="list-style-type: none"> <li>Responsible for the registration of seed companies, the release of varieties, seed quality control, and the certification of seed lots.</li> <li>Oversees tests on distinctness, uniformity and stability (DUS) and on value for cultivation and use (VCU).</li> </ul>
	Mozambique's Agricultural Research Institute (IIAM)	<ul style="list-style-type: none"> <li>Responsible for breeding and for basic seed production.</li> </ul>

Solynta stresses that the technology has been received positively in LMICs as local stakeholders see the potential.<sup>31</sup> HTPS allows local seed production, even if the seeds are imported you can still multiply locally via farm saved seed tubers. They do also mention that they experience a lot of politics to be involved, especially in getting varieties registered. Having demo plots for example where local (government) seeds are compared to HTPS is a delicate matter.

In forming an impact coalition, you need to address the question: What is in it for the (local) government and institutes and where do you need support? Who is funded by whom and which interests are threatened by a new technology? According to one of the interviewees an impact coalition (or big programme/project) of Dutch partners will not work as local stakeholders feel threatened and will not collaborate and might even counteract the initiative. To reduce local stakeholders to feel threatened working together with and involving those stakeholders in partnerships from the beginning is essential for success, even though this might slow down the process. In Mozambique for example, positive experiences exist in collaborating with the Zambezi Valley Agency, who are the leading partner in potato sector development activities. To deepen one's understanding on these topics a thorough context analysis including a stakeholder (power) analysis of the local potato sector is needed.

### At regional level – regional seed and trade associations

Variety registration is proven to be challenging at country level, that is why some interviewees stress the importance of investing in setting up regional procedures so you can get varieties registered in multiple countries at once. There are regional organisations actively working on this, though it is still the question how long the process and how effective the regulations will be. This could be a topic for Dutch companies working on (H)TPS to collaborate on as it lies in the pre-competitive sphere. The Dutch Ministry of Agriculture and sector organisations like Plantum or the Potato Platform within SeedNL could play a role in lobbying for these regional agreements. Below are some regional organisations that are involved in setting up regional seed and trade legislation in South-Eastern Africa:

<sup>31</sup> See D. Danial, M. de Vries, P. Lindhout, 'Exploring the potential of Hybrid Potato Cultivars in East Africa', November 2016. <https://knowledge4food.net/wp-content/uploads/2017/02/161130-Report-Solynta-mission-to-East-Africa.pdf>

### Common Market for Eastern and Southern Africa (COMESA)

COMESA is a regional semi-government agency that encompasses multiple countries in Eastern and Southern Africa<sup>32</sup>. Their main objective is to harmonise trade across their member countries: at a regional level COMESA has initiated a program (COMSHIP) to harmonize seed regulation.

### African Seed Trade Association (AFSTA)

The African Seed Trade Association (AFSTA) is a not-for-profit membership association formed in 2000 to champion interests of private seed companies in Africa. It is registered in Kenya as an International Organization with an office for West Africa in Dakar, Senegal. Currently, the Association has about 100 members comprising seed companies and National Seed Trade Associations, among others. They work amongst others on regional registration and trade regulations. Their vision is that all farmers in Africa have access to quality seed for food security. In October 2020, the ASFTA received a grant from the Bill and Melinda Gates Foundation to partner with seed companies and their national associations to co-design, test, and make recommendations for promotion campaigns that increase farmers' awareness of the benefits of replacing their older varieties of crops with newer seed.

### African Continental Free Trade Area (CFTA)

The African Continental Free Trade Area is a free trade area bringing together fifty-four African countries. The main objectives of the CFTA are to create a single continental market for goods and services, with free movement of businesspersons and investments, and thus pave the way for accelerating the establishment of the Customs Union. The CFTA was founded in 2018, with trade commencing as of 1 January 2021.

### East African Community (EAC)

The East African Community (EAC) is a regional intergovernmental organisation of 6 partner states: the Republics of Burundi, Kenya, Rwanda, South Sudan, the United Republic of Tanzania, and the Republic of Uganda, with its headquarters in Arusha, Tanzania. The work of the EAC is guided by its Treaty which established the Community.

As one of the fastest growing regional economic blocs in the world, the EAC is widening and deepening cooperation among the Partner States in various key spheres for their mutual benefit. These spheres include political, economic and social. At this moment, the regional integration process is in full swing as reflected by the encouraging progress of the East African Customs Union, the establishment of the Common Market in 2010 and the implementation of the East African Monetary Union Protocol". One of the aims of EAC is: "enhancing food security and rational agricultural and livestock within the Community through harmonisation of agricultural policies as well as joint programmes for efficient and effective production".

## **3.3.3 Dutch Government**

### **Ministry of Agriculture, Nature and Food Quality (MoAgri)**

The Ministry of Agriculture, Nature and Food Quality supports the agricultural councillors in their efforts to communicate with local governments on the import of seeds, registration and certification. There is specific expertise within the MoAgri on phytosanitary issues and breeders' rights.

The Netherlands Food and Consumer Product Safety Authority (Nederlandse Voedsel en Warenautoriteit, NVWA) is an independent agency within the MoAgri. The NVWA plays an important role in export inspections and has good contacts with their foreign counterparts. For the MoAgri and

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<sup>32</sup> <https://www.comesa.int/members/>

the NVWA it is most interesting if a coalition of Dutch companies requests their assistance on a specific issue.

The Dutch Ministry of Agriculture supported the Dutch potato sector by establishing a Holland Innovative Potato (HIP) Platform<sup>33</sup>. HIP is a Dutch association of 11 potato companies established to facilitate and coordinate joint pre-competitive research activities.

### **Ministry of Foreign Affairs (MoFA)**

The Ministry of Foreign Affairs (MoFA) supports sustainable potato sector development if it contributes to food and nutrition security. Small scale food producers are a central target group. When looking at seed sector development they focus on the benefits for small-scale farmers: informal seed systems and farm saved seed play an important role. From the countries selected for this study, Kenya is the only focus country of MoFA. Mozambique was a focus country, but interventions are now downscaled.

### **Embassies of the Kingdom of the Netherlands (EKN)**

The Dutch embassies in the focus countries were contacted and questioned on their policy regarding potato sector development, the interest in HTPS and past and ongoing initiatives related to the potato sector (see Table 6). EKNs in Kenya and Tanzania support the potato sector considering food security. Also Mozambique and Zimbabwe look for opportunities to support the sector. Kenya, Tanzania, Mozambique, Malawi and Zambia are interested in exploring the opportunities of HTPS. EKN Kenya referred to the risk of this innovation hindering other developments in the sector and advised to start small and position HTPS carefully.

Note: Topsectoren and RVO (as part of Dutch Government) will be elaborated upon in Financing Opportunities.

### **3.3.3 Dutch breeding companies**

Solynta was the first to believe and invest in the HTPS technology. Competitors say it was a good thing that they did, otherwise they would not have started that early to also explore the opportunity and scale- up their activities. Currently the main Dutch companies working on HTPS in LMICs are Solynta, Bejo Zaden, HZPC and Aardevo (joint venture of KWS and Simplot). These companies know each other and have regular informal contact. They have different opinions about the time horizon that is needed to develop and introduce quality HTPS varieties, the preferred distribution models and workable business models.

In the pre-competitive phase there is informal exchange through Plantum and Euroseeds. Solynta, Bejo Zaden, HZPC and KWS are also members of Holland Innovative Potato (HIP), an association of 11 potato breeding and processing companies, who participate in precompetitive research. There is however limited organized cooperation on pre-competitive topics like registration. The feasibility trial in Myanmar where Bejo and Solynta worked together is an example of formal collaboration to advance the HTPS technology.

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<sup>33</sup> <https://hollandinnovativepotato.nl/>

**Table 6. Embassies of the Kingdom of the Netherlands (EKN)**

Country	Focus Embassy	Attitude towards HTPS	Initiatives supported <sup>34</sup>
Kenya	For many years EKN supported potato sector development. They managed to get it on the agenda of the Kenyan government. Public institutions are involved, but unclear where responsibilities lie so getting procedures attuned is a challenge.	EKN invested in potato sector development a.o. for food security reasons. They welcome innovations and see the potential of HTPS, but also point towards the risk of introducing an innovation while it cannot be scaled yet (and might also obstruct other developments that are going on in the potato sector). So their advice is to start small and position HTPS carefully.	<ul style="list-style-type: none"> <li>• Seed Development Project Phase 1 (Mid 2011 – 2012)</li> <li>• Seed Development Project Phase 2 (2013-2015)</li> </ul>
Tanzania	Embassy supports potato sector development in light of food security. Potato is not seen as a cash crop (yet).		<ul style="list-style-type: none"> <li>• Center for Development of the Potato Industry Tanzania (CD-PIT)<sup>35</sup></li> <li>• MoU on Investment Government to government (G2G) project aiming to build capacity of Tanzanian regulators and Introduction of Dutch seed potatoes, mechanization, storage solutions, logistics and processing</li> <li>• Potato Impact Cluster and the Potato Strategy Development Plan (to be checked)</li> </ul>
Zimbabwe	Agriculture, and especially horticulture including potatoes is a priority in the strategic plan. Private sector development, food security and smallholder farmer development are key topics in agricultural development. Other important topics that the EKN is working on include water, renewable energy, climate change, women and youth empowerment and circular economy	Tubers from the farm are cheaper than seed. That is why farmers store seed tubers for next season which has a negative effect on their yields. Other options to increase production and food security are considered and new technologies to reach this goal are welcomed.	<ul style="list-style-type: none"> <li>• The Horticulture Development Council 2020-2023<sup>36</sup></li> <li>• Green Impact Centre<sup>37</sup></li> <li>• Building Model Farms in horticulture<sup>38</sup></li> </ul>
Malawi	Malawi is not a priority country for the EKN.	Interested to explore the potential of HTPS.	<ul style="list-style-type: none"> <li>• A few value chain projects were supported in the past, like macadamia and peanuts.</li> </ul>
Zambia	EKN does support some projects in Zambia (e.g. Lake Tanquana corridor development project) but there is no focus on horticulture or potato sector development	Interested to explore the potential of HTPS.	<ul style="list-style-type: none"> <li>• An agri-hub in Northern Zambia is under development. Focus will be on beans</li> </ul>
Mozambique	Beans, horticulture, cereals and soybeans have a higher priority, but EKN is working and has been working on potato sector development. Will get more involved in potatoes if there are opportunities for income improvement of smallholder farmers or if it can lead to more healthy diets.	Interested to explore the potential of HTPS to reduce transportation costs. An important EKN partner, the Zambezi Valley Agency, is also interested in HTPS	<ul style="list-style-type: none"> <li>• Project HZPC with Zambezi Valley Agency for 5-7 years (trials last year; no monitoring due to Covid-19)</li> <li>• Solidaridad-Solynta project not (financially) supported</li> <li>• Project with CIP on sweet potato varieties (?)</li> </ul>

<sup>34</sup> Information based on the interviews with embassies – list is not exhaustive

<sup>35</sup> <https://www.agroberichtenbuitenland.nl/landeninformatie/tanzania/achtergrond/latest-developments/cd-pit-project>

<sup>36</sup> The Horticulture Development Council was initiated in June 2019 and aims to reinstate the efforts of the HPC in supporting the horticulture industry in its development. HDC aims to serve as a platform for sector stakeholders to share information, facilitate trade, and provide services in order to improve production and processing operations.

<sup>37</sup> The Green Impact Centre (GIC) is a center for the Zimbabwean horticultural sector. It is an initiative of Greenworks Consultancy, Bakker Brothers, Klein Karoo Seed Marketing Zimbabwe, Delphy, Holland Greentech Zambia and Zimbabwe and supported by RVO. Together with the Green Impact Centre farmers they work on improving yields and post-harvest practices and create better opportunities to access finance and markets.

<sup>38</sup> <https://www.consultancy.africa/news/1185/pum-supporting-zimbabwe-with-establishing-model-horticulture-farms>

Multiple interviewees state that there is little room to work together in the competitive sphere. The business model is built around breeders' rights, so it is very important to be the first with the best yielding variety. It is expected that these companies will compete with their best varieties in the most favourable countries/regions at more or less the same time because they are in a similar phase of development. It is of general interest for these companies, for the Dutch potato sector and for the African countries to work jointly on challenging issues like registration and possibly infrastructure. Another reason to work together in a more structured way is to reduce the risk of failure which would lead to reputational damage of the Dutch potato breeding sector.

### 3.3.4 Dutch NGOs and Knowledge Institutes

During the interviews a number of organizations involved in potato projects were mentioned. These are listed below, but obviously a more tailored and in-depth stakeholder analysis is needed to identify potential collaboration partners in a specific country or region.

**NGOs working on potato sector development:** Solidaridad; Agriterra; SNV; Holland Greentech; Oxfam Novib. Holland Greentech has experience in capacity building on hybrid seeds in the horticulture sector (SEVIA project), which could be of value for an impact coalition on HTPS.

**Knowledge institutes:** Royal Tropical Institute (KIT); Wageningen University & Research; Van Hall Larenstein; AERES. Various WUR departments have relevant expertise on seed tubers and sector development: Wageningen Plant Research (PPO), Wageningen Department of Plant Sciences, Wageningen Department of Social Sciences and Wageningen Centre for Development Innovation (WCDI). If it becomes vegetable crop, WCDI has the most experience in capacity development and would be able to develop training modules on HTPS fast.

**Sector organisations and platforms:** Nederlandse Aardappel Organisatie/ Netherlands Potato Organisation (NAO); Vereniging voor de Aardappelverwerkende Industrie, the Dutch potato processing association (VAVI); Holland Innovative Potato (HIP, see paragraph 3.3.3); Netherlands Food and Consumer Product Safety Authority (Nederlandse Voedsel en Warenautoriteit (NVWA) (see paragraph 3.3.2); Nederlandse Algemene Keuringsdienst voor zaaizaad en pootgoed van landbouwgewassen, Netherlands General Inspection Service for seeds and starting materials of agricultural crops (NAK and Naktuinbouw (see paragraph 3.2); Agrofoodcluster; Plantum, the sector organisation for seed and young plants; SeedNL.

NAO is relevant for the overall potato chain, VAVI for processors, Agrifoodcluster for the whole potato sector/value chain, and Plantum for breeding companies. Plantum is less involved in international potato projects, but if knowledge sharing is needed at national level, it could play a role. Within SeedNL there is a Potato Platform and a precompetitive agenda could be shaped together with SeedNL.

### 3.3.5 International organisations

International organisations mentioned are International Potato Center (CIP); Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) with various potato programmes in Africa; TechnoServe: international non-profit organisation (e.g in Mozambique working on potato); International Fertilizer Centre IFDC (a.o. potato project in Uganda); International Institute for Tropical Agriculture (IITA).

The role CIP could play was explored during an exploration mission in 2016.<sup>39</sup> CIP has a strong presence in East Africa and may be helpful in exploiting the hybrid potato technology:

- CIP has a global mandate to develop potato varieties for developing countries.
- CIP has a strong research and dissemination platform in East Africa.
- CIP has unique germplasm that is valuable for hybrid potato breeding in East Africa.
- CIP has a strong network in East Africa that can be used for the dissemination of knowledge, technologies and materials.

The first contacts of Solynta with CIP on hybrid potato breeding date back to 2011 when the first presentation about hybrid breeding was presented at an EAPR meeting in Oulu, Finland. Initially, there was great concern and scepticism about the access of hybrid potato seeds to small farm holders in developing countries. Since then, CIP researchers have frequently interacted with Solynta on collaborative efforts of diploid genetic research and potato hybrid breeding. In 2016, it was agreed that CIP may play a role in pre-breeding research to develop tools for breeding like diagnostic markers and pre-breeding germplasm, like heat tolerance, as well as in the dissemination of knowledge and new hybrid cultivars to the small farm holders. CIP's role currently is a partner in joined R&D projects whereby CIP can contribute based on its unique germplasm and expertise. Joint R&D research on HTPS could be part of the regional programme in East Africa to develop a dedicated hybrid variety (Local Hero), but joint research on hybrid breeding with Solynta did not materialize to date. HZPC runs a bilateral breeding program together with CIP in Asia though this program is not focusing on HTPS.

### 3.4 Public-private financing

Private companies are not always interested in public funding. The business case should be clear from the beginning. Public funding puts pressure on certain topics or objectives, and businesses prefer to implement projects and invest themselves at their own pace. Projects need a long-term vision and investments while public finance often has a shorter time horizon. In developing countries and emerging economies potato sector developments are often not feasible without policy support from the Dutch government and funds from donors. Below an initial overview of funding agencies and instruments is given:

- Rijksdienst voor Ondernemend Nederland, Netherlands Enterprise Agency (RVO): Wide variety of financing instruments. For larger programs co-financing is often needed from the private sector. RVO is willing to think along with an impact coalition on the design of a program and looking for funding options.
- Topsector Agri&Food and Topsector Horticulture and Starting materials. Both Topsectors are familiar with hybrid potato and the directors have expressed their support for research on hybrid potato. Both Topsectors subsidise public / private research projects and have already funded several research projects on hybrid potato. Further support through seed money projects (30.000-40.000 Euro) is an option in which Wageningen University needs to be partner. No feasibility studies of technology, but a step further. Next to financing, the Topsectors provide human capital via e.g. Groenpact, and are willing to put topics on the agenda and endorse initiatives. Kenia/Tanzania are designated as priority countries regarding food security.

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<sup>39</sup> See D. Danial, M. de Vries, P. Lindhout, 'Exploring the potential of Hybrid Potato Cultivars in East Africa', November 2016. <https://knowledge4food.net/wp-content/uploads/2017/02/161130-Report-Solynta-mission-to-East-Africa.pdf>

- Nuffic, the Dutch organisation for internationalisation in education has programmes which may support capacity development in the potato sector. The Orange Knowledge Programme (OKP) is coming to an end and it is not yet clear if there will be a similar follow-up programme.
- Bill & Melinda Gates Foundation (BMGF) - potato not on their priority crop list; European Union (EU) - funding for large multi-stakeholder projects like HORIZON-CL6-COO-2022-00-00: Agro-ecological approaches in African agriculture systems; African Development Bank (AfDB); Dutch entrepreneurial development bank (FMO); International Finance Corporation (IFC); World Bank; USAID; Clinton Foundation; International Institute of Tropical Agriculture (IITA); Foreign, Commonwealth & Development Office (FCDO formerly DfID - Department for International Development).

## 4. Conclusions

### 4.1 Changing the food game

This scoping report describes important (groups of) stakeholders that need to be involved in sustainable potato sector transformation. Simons (2019)<sup>40</sup> describes in his book 'Changing the Food Game' what roles groups of stakeholders should play in different phases of sustainable market transformation (see figure 1).

Figure 1: Phases of Market Transformation

©from Changing the Game – Lucas Simons & André Nijhof	1. Inception	2. Competitive advantage	3. Pre-competitive collaboration	4. Institutionalization
<b>Industry</b>	<ul style="list-style-type: none"> <li>Stop denying the issue</li> <li>Partner with NGOs</li> <li>Pilots, CSR projects</li> <li>Identify solutions</li> </ul>	<ul style="list-style-type: none"> <li>Business models</li> <li>Use labels</li> <li>Engage value chains</li> <li>Rankings and benchmarks</li> </ul>	<ul style="list-style-type: none"> <li>Communicate a non-competitive agenda</li> <li>Join platforms</li> <li>Be inclusive</li> <li>Sector strategy</li> </ul>	<ul style="list-style-type: none"> <li>Lobby new normal</li> <li>Recognize politicians</li> <li>Comply legislation</li> <li>Take on subsequent issues</li> </ul>
<b>Government</b>	<ul style="list-style-type: none"> <li>Embrace the crisis</li> <li>Long-term vision</li> <li>Experiments and fund projects</li> <li>Solution principles</li> </ul>	<ul style="list-style-type: none"> <li>long-term vision</li> <li>Challenge companies</li> <li>Launching customer</li> <li>Recognize leaders</li> </ul>	<ul style="list-style-type: none"> <li>Develop measures</li> <li>Support platforms</li> <li>Influence behavior of consumers</li> <li>Tax incentives</li> </ul>	<ul style="list-style-type: none"> <li>Political leadership</li> <li>Announce legislation</li> <li>New normal</li> <li>Remove the laggards</li> </ul>
<b>NGOs</b>	<ul style="list-style-type: none"> <li>Raise awareness</li> <li>Join projects</li> <li>Campaign against laggards</li> <li>Argue for next steps</li> </ul>	<ul style="list-style-type: none"> <li>Reward first movers</li> <li>Support frontrunners</li> <li>Name and shame</li> <li>time to move on</li> </ul>	<ul style="list-style-type: none"> <li>Engage frontrunners</li> <li>Join platforms</li> <li>Be a watchdog</li> <li>Transparency about desired future</li> </ul>	<ul style="list-style-type: none"> <li>Lobby</li> <li>Policy developers</li> <li>Monitor progress</li> <li>Shift attention to new issues</li> </ul>
<b>Financial Institutions</b>	<ul style="list-style-type: none"> <li>Donate to charity</li> <li>Finance projects</li> <li>Apply negative screening</li> <li>Clear positioning</li> </ul>	<ul style="list-style-type: none"> <li>Provide funding</li> <li>Financial benefits</li> <li>Engage all clients</li> <li>Best-in-class screening</li> </ul>	<ul style="list-style-type: none"> <li>Join platforms</li> <li>Collaborate</li> <li>Create financial solutions for scaling</li> <li>Invest long-term</li> </ul>	<ul style="list-style-type: none"> <li>Lobby</li> <li>Investment criteria</li> <li>Exclude clients</li> <li>Potential risks linked to new issues</li> </ul>
<b>Research Institutions</b>	<ul style="list-style-type: none"> <li>Prioritize issues</li> <li>Study system loops</li> <li>Study practices</li> <li>Identify good practices</li> </ul>	<ul style="list-style-type: none"> <li>Showcase good practices</li> <li>Investigate failures</li> <li>Develop benchmarks</li> <li>Research agenda</li> </ul>	<ul style="list-style-type: none"> <li>Change agenda</li> <li>Be objective</li> <li>Calculate potential impacts</li> <li>Scientific evidence</li> </ul>	<ul style="list-style-type: none"> <li>Provide overview</li> <li>Argue policies</li> <li>Monitor impact</li> <li>Identify new and emerging issues</li> </ul>

(Hybrid) True Potato Seed has been in the inception phase for the past decade; breeding companies have been focusing on the technology and breeding the best varieties. Government has stimulated the innovation by funding research and (experimental) projects. NGOs were to a limited extent involved in this phase and in the projects where they played a role, they focused on raising awareness and capacity building of local partners and farmers.

The past years the innovation has moved to the competitive advantage phase. With this shift, the role of different stakeholders also needs to change if you want to realise sector change. As can be concluded from the interviews, the private sector is increasingly working on finding sustainable business models and thinking of/experimenting with how value chains can and need to be adapted. The government supports the innovation and the private sector, but they could also take up a role of

<sup>40</sup> Simons, L., 2019. Changing the food game: market transformation strategies for sustainable agriculture. 2nd Edition. Routledge, Abingdon.

developing (together with other stakeholders) a long-term vision for (Hybrid) True Potato Seed in the context of sustainable potato sector development.

The coming years it will be important to move into a more pre-competitive collaboration phase, where the private sector implements a non-competitive agenda, joins (local or regional) platforms and works on a sector strategy (this could be part of the long-term vision of the government). In this phase it is needed to join forces on subjects where individual companies do not have enough leverage or lobbying power. The government should support this sector collaboration and platforms.

NGOs should increasingly be involved in sector transformation projects or initiatives. Their role is to raise awareness and support frontrunners with their capacity building experiences and local network. Research institutes should develop a research and change agenda on what system change is needed to sustainably implement HTPS and the social, economic and environmental impact of implementing HTPS. Multiple interviewees point towards experience gathered and lessons learned on these topics in other sectors, like horticulture, that could provide important insights.

(Local) financial institutions did not get specific attention in this scoping report, but they are an important player. Especially in years to come, when public money will decrease and sustainable (input, output and investment) financing, also for the small-scale farmer, needs to be in place. It is advised that in future initiatives, like impact clusters or project/programmes, this actor gets more and more involved.

## 5. Recommendations; the way forward

This chapter describes recommendations based on the information gathered and analysed in this report. There will also be a reflection on the main research question: whether an impact coalition on HTPS is possible and desirable as a next step to sustainably implement HTPS.

### 5.1 Public-Private pre-competitive agenda

Collaboration of the private sector in the competitive sphere is challenging, but there is room to develop a public-private pre-competitive agenda. The collaboration could be shaped around the following topics:

- **The development (and implementation) of an action-research agenda** that moves from a technological focus towards what is needed to realise system change. Main research topics include: What is needed to sustainably implement HTPS? What could be the potential impact? What are sustainable (seed) systems and value chains? How to organise capacity building and increase adoption rates? What are sustainable business models?

This research agenda generates most valuable insights if action-research is done in a specific country or context. Developing **roadmaps for change** could be an option. A critical success factor is to learn from other sector transformation experiences, for example in large horticultural (seed) projects in LMICs (e.g. HortInvest, SEVIA, ISSD). The Holland Innovative Potato Platform (HIP) is also a good example as it succeeded in organising a five-year multi-company research programme. All HIP companies, WUR and UU are aligned and enthusiastic. The development and implementation of an action-research agenda could be discussed with (and possibly facilitated by) Plantum and/or (the potato platform within) SeedNL.
- There is still a lot to gain by **collaboration on import and registration** as individual companies are now all paving their own way. Registration institutes would be helped with examples of HTPS registration in other countries as was done in Kenya (where the example of South-Africa was used). It would also help if there is a clear process of registration of hybrid potato within the EU. One can then use this EU registration as a “gold standard” in LMICs to show there is reason for “fast track” a hybrid. An advice is to also look (for seed and registration) at the possibilities of regional organisations instead of local institutes.
- All parties are benefitted by **increased awareness creation**. There is need for a joint-communication strategy, in order to stimulate a change of perception towards HTPS among farmers and other stakeholders. This could be done through media, demonstration plots and field days, with a role for Ministries of Agriculture and National Agricultural Research Stations (NARS).
- There is also the need for **increased public-private collaboration for enabling policies and regulations**. The future of HTPS should not solely be in the hands of the private sector. To realise changes in the enabling environment, the public sector should take up their role as change maker and facilitator by using their influence and contacts with public institutes, support (the establishment of) potato sector platforms, and develop or support a joint vision for the future of HTPS.

The above recommendations focus on the pre-competitive phase as this is a safer place for collaboration. In addition, a lot can be gained in the competitive phase, if private sector companies find ways to overcome or work around competitive bottlenecks. Two concrete ideas came out of this scoping study:

1. HTPS is now in the phase that 1-3 varieties can be introduced in local markets. The registration of these varieties is a challenge, but changing mindset and culture is an equal big challenge. Stakeholders need to embrace a new way of producing and cultivating potato and 'seeing is believing' is essential in this process. It was mentioned by several interviewees **that branding and awareness creation (for both public institutes and farmers) could be done through a local demonstration, information and innovation centre.** In this centre companies working on HTPS work together to show the potential of HTPS. As one of the interviewees explains: "we are now focussing too much on business models, but that is too early: millions of farmers have never heard of hybrid true potatoes".  
Sharing infrastructure is however a sensitive issue. In a mature market, whereby breeding companies have successful cultivars in the market, it will not be difficult to organise regional or national trials with the cultivars from these companies as these cultivars are already in the market. However, this is not the situation yet with hybrid potato. Companies are still in the phase of testing pre-commercial cultivars which are their treasures and as a consequence, these companies are not prepared to share trials and information on these cultivars.
2. Setting up or changing a value chain comes with investments in capacity development and lies often in the competitive sphere. However, as producing and cultivating HTPS requires quite some **additional skills from farmers and stakeholders involved in capacity building**, working together on this topic could be a good investment. In the horticultural sector, companies have started to work together with a higher education institute, HAS, in a joint learning and training strategy for horticulture sector entrepreneurs and workers. The coalition intends to take the activities of Dutch horticulture and education actors in this field to a higher level, generating a more sustainable impact of capacity strengthening investments and projects, making sure there is more alignment, and enabling the resources and time invested in it to benefit lasting impact.<sup>41</sup> A joint-capacity building trajectory could be supported by the Green Education institutes and/or the Agrofoodcluster and linked to a demonstration centre.

## 5.2 Impact Coalition

The main research question of this scoping study was whether an impact coalition on HTPS is possible and desirable as a next step to sustainably implement (H)TPS. This scoping study concludes on three possible forms of impact coalitions:

1. A coalition in the form of an **Impact Cluster** on HTPS. A public-private impact cluster (with Dutch and local partners) could be formed to sustainably introduce HTPS. An impact cluster is a collaboration around specific outputs where public-private collaboration is essential. An example is the Dutch Bangla Potato Support Impact Cluster.<sup>42</sup> The report of the HTPS trial in Myanmar also suggests forming an impact cluster as a next step. One of the interviewees mentions that a key success factor to form an impact cluster is a facilitator/coordinator who

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<sup>41</sup> [https://www.nlfoodpartnership.com/impact\\_coalitions/skills-horticulture/](https://www.nlfoodpartnership.com/impact_coalitions/skills-horticulture/)

<sup>42</sup> <https://www.dutchbanglapotatosupport.com/>

stands above the parties and who has enough content knowledge and respect to bring parties together.

2. Form an **implementing Impact Coalition**. A second option is to start a pilot program with a coalition of Dutch and local breeding companies, local government (institutes), and (local) NGOs. Several interviewees mention that in this stage of the technology one should keep it small and focussed with clear, tangible objectives on next steps needed to reach the potential of HTPS. The initiative of Solynta to start a programme on **Ecologically and economically resilient potato** (Ec2Pot) would require such an impact coalition. A pilot-programme aiming at building a local potato production system with seedling raising, seed tuber multiplication and ware tuber production, could focus on different models (single farm, community, region) depending on the ambition level and the feasibility of the business case.
3. A third option could be to **become part of an existing coalition, a coalition in development or develop a broad coalition**. In this scenario, a company working on HTPS would become part of or larger potato or horticulture sector development program, for example the potato sector development program that is being set-up in Uganda (a.o. by IFDC, KIT) or the SDGP Potato project in Rwanda<sup>43</sup> or a larger seed sector transformation program like for example ISSD (not operational at the moment in focus countries, but ISSD does work in Ethiopia, Nigeria and Myanmar). The ambition would be to give a particular region access to suitable varieties, capacity to grow clean propagation material, the required agronomic knowledge, a suitable infrastructure and enabling laws and regulations. Many challenges of introducing (H)TPS also apply to the seed potato route and both systems could contribute to that ambition. It is acknowledged that this scoping study did not collect sufficient data to decide on specific activities regarding a significant (pilot)programme/coalition in one of the selected focus countries, but the following considerations could be considered.

The existing potato infrastructure and market are favourable in countries like Kenya and Tanzania, but bureaucratic challenges and vested interests make it difficult to operate and move forward with an innovation like HTPS. It could be beneficial to make use of experiences and contacts of larger sector/system change programs to realize change. As there are multiple bigger seed, potato or horticultural programs running or being developed, it would be an option to join one of these programs in these countries.

The interest of multiple companies working on HTPS in Zambia, together with a growing potato market and a supportive attitude of the local government and the EKN could be an interesting country to scope for the possibility of an Impact Cluster (combined with a demonstration centre). Mozambique could be an interesting country to start an implementing impact coalition, as some companies have already experience in working together with NGOs in a HTPS implementing program. For both countries funding from Dutch government (institutes) is limited so other sources of funding should be searched for.

Uganda and Rwanda were not part of the chosen focus countries, but during this research it became clear that opportunities for HTPS exist in these countries. It could be considered to look at these countries for next steps.

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<sup>43</sup> Increased Potato Value Chain Efficiency in the Great Lakes Region (SDGP project).  
<https://delphy.nl/wp-content/uploads/2019/11/SDGP-Rwanda.pdf>

## 5.3 Next steps

If there is joint interest to start an impact cluster or implementing impact coalition, a **local scoping study** in the country of preference is needed. To reduce the risk of failure of new technologies such as HTPS, multiple stakeholder assessments may be needed to gain sufficient insight into critical but still unknown circumstances. A scoping study should also study legal requirements, advice on how Dutch and local companies could collaborate, what the business model and market size is, how smallholder farmers will benefit also in case there is competition with seed tubers. A local scoping study should not be limited to identifying possible partners for an impact cluster or coalition but should look at questions like: who has which interests in the potato sector? Who will be benefitted by HTPS and who will not? Who is threatened by this technology? From whom do you need support? It is also important to look at streams of finance: who gets what money from whom? Based on an analysis of these issues, a stakeholder strategy could inform the formation of a cluster or coalition.

More targeted is the other way round: find relevant stakeholders and potential coalition partners, **start building a partnership/coalition** which will in an inception phase do the required scoping and assessments as mentioned above, develops an ambitious programme, and looks for funding. This approach is more focused and raises commitment of all partners during the design phase.

## Annex I: List of interviewees

	Name interviewee	Organisation	Function	Date interview
1	Charles Miller	Solynta	Commercial Director	23-03-2021
2	Michel de Bruin	Agrico	Manager Development	26-03-2021
3	Gerard Backx	HZPC	CEO	08-04-2021
4	Rien van Bruchem	Bejo Zaden	Area Crop Manager	16-04-2021
5	Paul van den Wijngaard	Aardevo	Managing Director	30-04-2021
6	Erika den Daas	Meijer	Director	21-05-2021
7	Dick Hylkema	Nederlandse Aardappel Organisatie (NAO)	Director	08-04-2021
	Karst Weening	NAO	Responsible for market access and international potato projects	08-04-2021
8	Cor van Veldhuijsen	Agrofoodcluster	Managing Director	09-04-2021
9	Yeray Saavedra	Wageningen University Centre for Development Innovation (WCDI)	Advisor Horticulture & Sustainable Markets	29-03-2021
10	Walter de Boef	WCDI	Senior Advisor Seed Systems	19-04-2021
11	Marja Thijssen	WCDI	Senior Advisor Seed Systems	02-04-2021
12	Abiskar Subedi	WCDI	Senior Advisor, Genetic Resources and Seed Systems	07-05-2021
13	Busie (Sibusisekile) Gomez	EKN Zimbabwe	Policy officer Trade and Commercion, Zimbabwe, Malawi	01-04-2021
14	Ernesto Sechene	EKN Mozambique	Policy Officer Food & Nutrition Security	12-04-2021
15	Frank Buizer	EKN Uganda	Agricultural Counsellor	14-04-2021
16	Ingrid Korving	EKN Kenia	Agricultural Counsellor	31-05-2021
	Bart Kuitert	EKN Kenia	Agricultural Attaché	31-05-2021
17	Astrid Broekaart	RVO	Programma Coordinator Mondiale Vraagstukken	13-04-2021
	Lanthe Nieuwenhuis	RVO	Project advisor SGDP and FDOV	13-04-2021
18	Willemien van Asselt	Topsector Agri&Food	Director for International Relations and Cooperation	09-04-2021
	Anneke van der Kamp	Topsector Tuinbouw & Uitgangsmaterialen	Member of the Topteam	09-04-2021
19	Inge Tenniglo	Ministry of Agriculture (MoAgri)	Food Security Policy officer	09-04-2021
	Arno Rohde	MoAgri	Coordinating policy officer at Agribusiness International	09-04-2021
20	Lianne Kersbergen	MoAgri	Senior Policy Officer Phytosanitary Market Access	02-04-2021
21	Astrid Mastenbroek	Ministry of Foreign Affairs (MoFA)	Senior Policy Advisor Food & Nutrition Security at Inclusive Green Growth	26-04-2021
22	Heleen Bos	Rijk Zwaan	Account Manager Organics	07-06-2021

## Annex II: Guiding questions interviews

Note the guiding questions were adapted to the interviewee and their organisation. Some questions were not relevant and hence not asked during the interview. Where relevant it was asked to give answers for each focus country.

Level	#	Question
General	1	Could you shortly introduce yourself and your position within your organisation?
Activities	2	What activities is your organisation performing in the focus countries?
		Demo (One or more hybrids in sales demo trials)
		Registration (One or more hybrids in national registration trials)
		Screening (Testing of multiple early selection hybrids)
		In what regions?
	3	What stage of activity is needed to implement an HTPS sector program in a country?
		What is timeline for different activities in countries?
		Do you foresee challenges in the activities that are necessary to implement an HTPS program? If yes, which ones?
	4	With which authorities/local institutions does your organisation have relations at the moment?
		At national level
		At regional level
		At local level
	5	How would you describe the relations of your organisation with these authorities?
	6	Which authorities are key in setting up a successful HTPS sector program?
Enabling environment	7	How important is potato sector development in the national policy?
	8	What is their strategy towards seed potato development?
	9	What is the attitude of the authorities towards HTPS?
		At national level
		At regional level
		At local level
	10	How would you describe the enabling environment (e.g. rules and regulations) for implementation of HTPS?
	11	How would you describe the relations of HTPS companies with the Dutch Embassy?
	12	What is according to you their attitude towards potato sector development in general?
		and True Potato seed in particular?
Funding	13	Are your activities or projects funded by public money? If yes, which ones?

	14	Who are the funding agencies?
	15	Which potato programs and projects did the embassy support (financially) currently and in the recent past?
	16	Which funding mechanisms are available for potato sector development projects and programs at the embassy or other Dutch funders (RVO, ...)?
	17	Could the embassy advise on other potential, international donors?
Partners	18	Which organisations are working on potato sector development?
		Dutch
		Local
		International
	19	Which organisation are working on HTPS?
		Dutch
		Local
		International
	20	What programs or projects are working on potato sector development or HTPS?
	21	Which organisations are most interested to work together on the HTPS sector approach and why?
	22	Which organisations are not? For what reasons?

## Annex III: Potato breeding and multiplication systems

Pim Lindhout, June 7<sup>th</sup>, 2021

### Introduction

Potato is the globally most important not-cereal crop. There are three different aspects that are relevant for breeding and multiplication: Multiplication system, ploidy level and breeding system. These three aspects are outlined below:

### Multiplication system

#### Vegetatively (clonal)

Traditionally, cultivated potato (*Solanum tuberosum*) is reproduced vegetatively: part of the plants are used as starting material to cultivate the crop. These can be tubers, mini-tubers or cuttings.

#### Tubers

Reproduction by saving and planting (seed-) tubers is by far the most dominant system of potato reproduction worldwide. Each potato plant may produce five to twenty tubers and hence the reproduction factor is on average ten. It is a very easy applicable system as farmers may just harvest the tubers and separate them for sales at the (local) market, for consumption by their own family or as starting material for next cropping season.

It is most efficient to keep the best and smaller tubers for starting material for next crop. However, often tubers are smaller because of infections by some of the over 200 pathogen and pest species, that may infect potato plants. If these diseased smaller tubers are used for planting in next season, the yield will be reduced as the plants are already infected from the beginning of the crop growth. This is the main reason for reduced yields at farms where they use “farm saved seed”. This is referred to as the informal seed system, that represents over 90% of the potato cultivating area.

There are companies, designated seed tuber companies, who are specialised in producing seed tubers at conditions, that reduce the chance of infection, mainly by insects like aphids that are the vectors for virus transmission. These conditions are more favourable when the crop is grown close to the sea, as this reduces and delays the occurrence of aphids. Therefore these companies are concentrated in The Netherlands, Scotland and Denmark.

This formal production of seed tubers and the commercialisation including rules and regulations, is referred to as the “formal seed system”, that covers less than 10% of the global potato cultivation area.

#### Mini-tubers

During each round of vegetative tuber production in the field some infection may occur. As a result, eventually seed tubers are heavily infected and not suitable for starting new cultivations. In the formal system ware farmers use commercial seed tubers that are generated after five to eight generations by the formal seed tuber producers. In the informal system, farmers may apply farm saved seed up to 18 generations.

Professional seed tuber producers will regularly start a fresh cultivation from plants or plantlets, that are kept in under artificial *in vitro* conditions as this is the best way to maintain a disease free stock. These plants are too weak for growth in the field and therefore are raised in greenhouses to produce mini-tubers. This is an expensive cultivation and the price for high quality mini-tubers is about 0,50 €. These are reproduced several years to dilute these high costs over the progeny tubers. Usually, the fourth generation is the first generation that is used by commercial farmers to produce ware tubers. The mini-tuber propagation system is usually controlled by the owners of the cultivars. These are the breeding /trading companies (NL: Handelshuizen) like HZPC and Agrico.

### **Cuttings**

As an alternative to produce relatively healthy starting material, CIP advocates the usage of cuttings from greenhouse grown plants. These are raised in nurseries to small plants that are used as starting material by farmers. This system is tested in Kenya, Africa.

### **Generatively**

As an alternative for the seed tuber propagation system, CIP started with producing true seeds from berries, that are used as starting material for a potato crop. This is designated True Potato Seed (TPS). The advantage of TPS is the relatively easy, fast and efficient way to produce large quantities of seeds: One plant may carry ten to hundred berries and each berry may contain fifty to two-hundred seeds.

### **Open pollinated**

Initially CIP took advantage of spontaneous set berries from a population of (selected) plants grown in the field. These berries will carry a mixture of selfed seeds and seed obtained after outcrossing.

### **Crossings**

TPS can also be produced by making manual crosses by collecting pollen from the male parent, removing the anthers from the female parents and putting the pollen on the stamen of the female flowers. These seeds are designated “hybrid seeds”. This seed production system is quite labour and time intensive, but each manual cross may result in over hundred of seeds, which may keep seed production costs per seed at an economic level.

## **Ploidy level**

Ploidy level refers to the number of copies of the total genetic information (also referred to as “genome”) as present in the chromosomes. The basic number of chromosomes in potato is twelve. So, haploid potato containing one copy of each chromosome has only twelve chromosomes. Chromosomes are extremely complex as usual, the total number of genes is some 30,000. So, each potato chromosome carries some 2500 genes. These genes are unique sequences with regulation signals, coding regions and extra-cistronic regions. These “islands of unique coding sequences” are embedded in oceans of repetitive sequences and pseudogenes, whose function is largely unknown (not relevant for this document but for the interested reader).

### **Tetraploid**

Tetraploid plants have four genomes: four sets of chromosomes. Tetraploid potato has  $4 \times 12 = 48$  chromosomes. Each gene is represented by four copies, that may be identical (= homozygous) or different (= heterozygous).

## Diploid

Diploid plants have two genomes: two sets of chromosomes. Diploid potato has  $2 \times 12 = 24$  chromosomes.

## Breeding system

### Vegetative crop

Traditionally, potato breeding is straightforward: two parents are crossed and the progeny is sown and vegetatively propagated over five to ten years under constant evaluations of important traits, finally resulting in a stock of some hundreds of tubers of the same genotype, that is registered as a new cultivar. These tubers are further propagated for another three to five years to generate sufficient numbers of seed tubers to cultivate potato to produce ware potato tubers for fresh consumption or for processing. When the new cultivar is successful, its area of production is gradually increased, restricted by the reproduction factor of about ten, typical for seed tuber production in the field. Eventually, mini-tubers can be produced to boost production of larger numbers of potato tubers. This system of potato breeding is done by public breeders, private breeders and hobby breeders, who may be associated with breeding companies or act independently.

### Generative crop

As stated above (Chapter 2.2.), CIP has developed a breeding and reproduction system that is based on True Potato Seed (TPS). Several breeding systems can be applied that all result in true potato seed. These breeding systems are often not very well described and hence lead to confusing terminology. In this overview TPS is used to indicate the type of starting material: True Potato Seed. From a breeding point of view, we describe two discrete breeding systems: open pollinated breeding and hybrid breeding.

#### Open pollinated

Initially, CIP applied mass selection in open pollinated populations. In this way, superior phenotypes are selected, maintained as a populations to produce progeny plants though open pollinations. These berries will contain a mix of seeds from selfings and seed obtained by cross pollinations. As a result, TPS produced in this way is genetically very diverse. It was expected that low income farmers may embrace this variation in their own potato crop. However, also low-income farmers prefer a more uniform crop. This is the main reason, why the usage of this TPS system is declining.

#### Hybrid breeding

To prevent contaminations with spontaneous selfings and to promote outcrosses, superior individual plants are selected and intercrossed. The populations of selected plants are combined as a female pool or as a male pool and crosses between individual plants of these pools are made to produce hybrid seeds. As the progenies seeds are obtained after deliberately crosses between two individual plants, these can be considered as hybrids. This has two advantages: First of all, these hybrids will not contain selfed seeds, that may suffer from inbreeding depression and secondly, they may even show heterosis, a phenomenon, that is typical for hybrids.

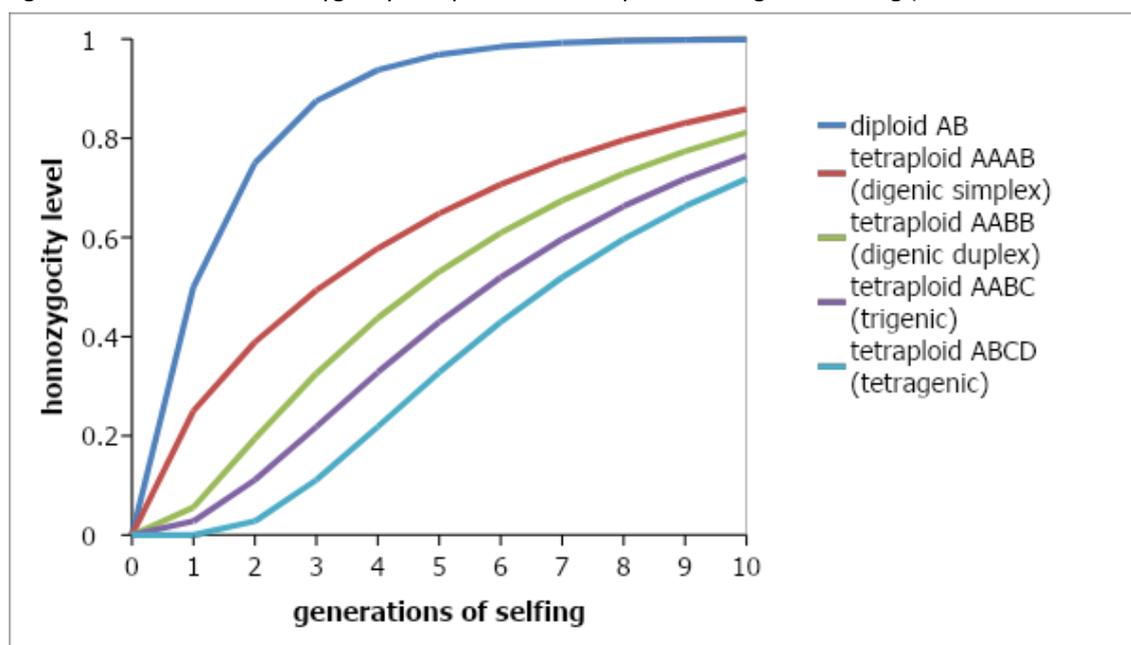
This system of “hybrid TPS” has been used in many countries in Africa and Asia, but is gradually abandoned as also these hybrid seeds showed too much genetic variation. This is due to the very heterozygotic character of potato, especially when tetraploids are used, that may show four different

alleles at each locus (See also Chapter 3). So, some level of improved uniformity is reached, but this is by far remote from the uniformity of “pure hybrids” that are based on homozygous inbred lines.

### Highly inbred (HIP)

To reduce the number of heterozygous loci (and reduce the number of segregating alleles), usually five to ten generations of inbreeding are applied to produce homozygous parent plants to generate hybrid seeds. This is typical for true hybrid breeding in many diploid crops like corn, tomato, cucumber, sugar beet and many other crops. When this is done for a tetraploid crop like potato, many more generations are needed to generate homozygous parents (see Fig. 1).

Fig 1. The increase in homozygosity in diploids and tetraploids through inbreeding (From Lindhout et al., 2018).



The generation of homozygous parents is much faster at the diploid level. The cultivated potato is a tetraploid crop, while diploid potato is also available (See Chapter 3.). Therefore Lindhout et al. (2011) choose to start with diploid potato plants to generate homozygous inbred parents. However, diploid potato is self-incompatible, meaning that it cannot produce selfed progenies. This was overcome as some wild diploid species are self-compatible and this trait has been introduced into cultivated diploid potato from *S. chacoense*. This allowed to start an inbreeding programme. This was hampered by severe inbreeding depression, that was overcome by continuous rounds of inbreeding and crossing inbred lines, in genetic terms by removing the deleterious alleles (Linhout et al., 2018).

The results of this continuous inbreeding programme are highly homozygous parents, that are crossed to produce heterozygous but homogeneous and hence uniform hybrid seeds. It took some years and many generations of dedicated breeding to generate the first hybrids that showed similar yield as traditional tetraploid cultivars (Stockum et al., 2020).

Hybrid breeding has the additional advantage that single genes can easily, effectively and fast being introduced by applying marker assisted breeding (MAB). Already in 2017, Solynta has shown to use MAB to introduce two genes for resistance to *P. infestans* in only two years, while the genetic make-up was remained unaltered (Su et al., 2020).

This is the programme that Solynta is advocating, while HZPC and Aardevo are probably using the same technology.

*Slightly inbred (SIP)*

Bejo is using a different approach as a limited number of inbreeding generations are applied at the tetraploid level. This will result into an increase of homozygosity but these small number of generations is not sufficient to produce highly homozygous parents. As a consequence, such hybrids may have a higher level of uniformity, but not at the level of hybrids generated from highly inbred parents.

*Breeding summary*

In summary, there are several breeding systems being used in potato, though the vegetative breeding is still the dominant system. Table 2 summarizes the main characters of these breeding systems.

In 2021, the potato breeding company Meijer submitted a TPS cultivar for registration by the Dutch authority (NAK). The breeding technology applied is different from all mentioned breeding systems in this document and is considered as confidential.<sup>44</sup>

**Table 1. Main potato breeding systems.**

	<b>Vegetative system</b>	<b>TPS (including SIP)</b>	<b>HTPS (HIP)</b>
Ploidy level	tetraploid	tetraploid	diploid
MAB introduction one gene*	10 - 20 years	10 - 20 years	2 - 3 years
MAB introduction two genes*	> 25 years	> 25 years	3 - 4 years
Multiplication	tubers (5 - 10 years)	seeds (one season)	seeds (one season)
Seed health**	higher chance on contamination	clean	clean
Uniformity	high	low	high
Commercial interest	proven	limited	growing
Conclusion	Dominant system: Russet Burbank is leading cultivar for > 140 years	CIP introductions: mainly in developing world, area is declining	Potential: dynamic introductions of innovative products, value creation, disruptive change

\* The "one gene" and "two genes" refer to genes from wild relatives, not genes already present in the commercial varieties.

\*\* By definition, diseases occur every season in a potato field, also in a seed potato production field. The NAK certifies seed potatoes, setting maximum standards for contamination. This determines the class in which the seed potatoes are sold. The Netherlands has favourable seed potato production regions, near the sea, where fewer insects and therefore also viruses occur. In addition, there is a lot of tradition in growing seed potatoes, which gives the Netherlands a reputation for producing high quality seed potatoes (= low disease infections). Other countries – certainly most Low- and Middle-Income Countries - have more virus pressure and less expertise. Real clean cultivation is therefore impossible, unless work is done in sterile quarantine greenhouses. This is theoretically possible, but practically too expensive and technically very difficult.

<sup>44</sup> Guus Heselmans, personal communication

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