KENYA SEED POTATO INDUSTRY DIAGNOSTIC

Increasing Seed Potato Availability in Kenya: Priority Investments and Policy Actions

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ACRONYMS

ADC	Agricultural Development Corporation
C1	Certified third generation
C2	Certified fourth generation
C3	Certified fifth generation
CIP	International Potato Centre
COMESA	Common Market for Eastern and Southern Africa
COMSHIP	COMESA Seed Harmonization Implementation Program
COPE	Centre of Phytosanitary Excellence
DUS	Distinctiveness, Uniformity, and Stability
EAC	East African Community
EGS	Early Generation Seed
ESWS	Electronic Single Window System
FAO	Food and Agricultural Organization
IPPC	International Plant Protection Convention
ISPM	International Standards for Phytosanitary Measures
ISTA	International Seed Testing Association
KALRO	Kenya Agricultural and Livestock Research Organization
KEPHIS	Kenya Plants Health Inspectorate Services
OSBPs	One Stop Border Points
NPPO	National Plant Protection Organization
NPT	National Performance Trials
OECD	Organization for Economic Co–operation and Development
PCN	Potato Cyst Nematode
PPP	Public-Private Partnership
PRA	Pest Risk Analysis
QDPM	Quality Declared Planting Materials
QDS	Quality Declared Seed
SADC	Southern African Development Community
SPS	Sanitary and Phytosanitary
UPOV	International Union for the Protection of New Varieties of Plants
VCU	Value for Cultivation and Use

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OPERATIONAL DEFINITIONS

Aeroponic System	A method where plants are grown in air or mist environment without the use of soil or an aggregate medium.
Apical Cutting	The cutting of the tip of mother/ tissue culture plantlet to be grown for propagation.
Basic Seed	Also known as Foundation seed. The progeny of pre-basic seed, used as planting stock for registered and certified seed.
Breeder Seed	A seed which has been produced by a person or institution responsible for the maintenance of the cultivar or variety.
Certified Seed	A seed of a prescribed standard of quality, produced under a controlled multiplication scheme, either from basic seed or from a previous generation of certified seed. It is intended either for the production of a further generation of certified seed or for sowing to produce food or forage.
Cultivar	Synonymous with the term "variety". Subdivision of any seed species which can be distinguished from other subdivisions of the species by growth, plant type, flower or other physiological characteristics.
Cutting	A seedling produced from a tissue culture plantlet by snipping, i.e. stem or apical tip used for propagation or production of ware potato.
Distinctness Uniformity and Stability (DUS)	These are tests to determine whether a newly bred variety differs from existing varieties within the same species (the Distinctness part), whether the characteristics used to establish Distinctness is expressed uniformly (the Uniformity part) and that these characteristics do not change over subsequent generations (the Stability part).
Dormancy	The condition in which a seed with a viable embryo fails to germinate in conditions conducive to plant growth.
Early Generation Seed	Seeds in the earlier production stages i.e. breeder and foundation seed.
Farmer	A person who owns works on or operates an agricultural enterprise that cultivates land for crops.
Field Inspection	Examination of a crop seed field including checking for effective isolation distance, hectarage of the seed field, off-types, foreign cultivars and diseased plants as part of the seed certification program.
Hydroponic System	A method of growing plants without soil by instead using mineral nutrient solutions in a water solvent.
Isolation	The separation of the field of seed crop from the field of other crops to prevent mechanical or genetic contamination of the seed to be harvested. Isolation could be in the form of distance, time and physical barriers.
Labelling	The process of KEPHIS or NPPO affixing a tag or mark of identification as an assurance of correct identification of any container seed to ascertain certification.
Mini-tubers	Progeny tubers used for propagation of production of ware potato.
National Performance Trials (NPT)	Also referred to as Value for Cultivation and Use (VCU). These are trials to establish in respect of other registered varieties, differences in productivity, biological characteristics, quality of the obtained produce, chemical and technological characteristics, resistance to pests and diseases, as well as other commercially important characteristics and growing suitability under local agro-climatic conditions.

Off-type	A plant in a seed crop that deviates from the typical description of the cultivar.
Phytosanitary Certificate	A certificate issued by a legally constituted authority of the federal or state government stating that a seed lot has been inspected and found to be free of quarantine diseases. These certificates are frequently used in international seed trade agreements to prevent the spreading of seed-borne diseases among countries.
Positive Selection	Choosing and marking of the best plants in a ware field as mother plants to provide for seed for subsequent seasons; done by ware potato farmers.
Pre-basic Seed	A progeny of breeder seed.
Propagation	Breeding of specimens of a plant or animal by natural processes from the parent/mother plant.
Quality Declared Seed	A seed that meets at a minimum agreed-upon standard of quality. It may entail some inspection by the official seed certification system or ministry of agriculture officials. Its use is usually regulated and restricted to a given locality in a country.
Quarantine	The restriction on the movement of seed to prevent the spread of disease or pests.
Registered Seed	A class of seed in a certified seed scheme that is produced from foundation seed and planted to produce certified seed.
Registered Seed Merchant	A person or institution or firm officially recognized by the seed regulation committee as suitable to produce, process or sell seed potato.
Sampling	The method by which a representative sample is taken from a seed lot to a laboratory for analysis.
Seed	That part of a plant used for propagation. It includes any cutting or tubers.
Seed Class	A stage in seed multiplication system well defined in respect of parental seed standards of cultivations and seed quality.
Seed Inspector	A suitable qualified person on the staff of the official inspection station.
Seed Lot	A quantity of seed of one cultivar, of known origin and history, and controlled under one reference number.
Seed Quality	The potential performance of a seed lot with characteristics based on trueness to variety.
Seed Testing	The examination of a sample of seed to determine its quality to produce a specific commercial crop.
Seed Certification	The act of ascertaining whether seed has met required minimum standards.
Smallholder Farmer	A farmer owns or cultivates a small piece of land on which they grow subsistence crops and one or two cash crops relying almost exclusively on family labour. In Kenya, smallholdings classify as being below 5 hectares; the average is 2 hectares for ware potato farmers.
Vegetative Propagation	Growing new plants from parts of the parent plant; for this study: tubers and cuttings.
Zero-Tolerance	Zero-tolerance in seed potato refers to the total ban of any planting material with the globally recognized pathogens for bacterial wilt, potato cyst nematode and other significant pests and diseases.

AT A GLANCE: SEED POTATO PROPAGATION IN KENYA

Summary of Issues and Recommendations

Propagation Material

KALRO

Issue
- Low funding levels for R & D to develop enough breeder seed

Key Recommendations:
- Increase participation/collaboration of private seed companies in production

Imports

- Similar to those of basic seed

Issue
- Pests and diseases

Key Recommendations:
- Consider the application of risk-based seed import licenses. Review and revise zero-tolerance policies
- Set up of laboratories and quarantine facilities for seed and ware imports for fast-tracking inspection
- Training of inspectors on emerging best practices like the use of Loop mediated isothermal amplification (LAMP) and genome sequencing (PCR)
- Purchase of modern high-speed seed inspection equipment. See pages 27-30 for details

Seed Multiplication

See pages 15-20

Hydro ponic

Issue
- Initial set up costs are high; requires high levels of technical expertise

Key Recommendations:
- KEPHIS, seed companies to recruit TC experts and extension agents
- Leverage investments and capacity to increase TC seed potato through PPPs

Hydro ponic

- Similar to those of hydroponics

Positive Seed Selection

Seed Plot Technology

Issue
- Inadequate farmer skills in seed production

Key Recommendations:
- PPP on improving extension and farmer training on the use of Positive Seed Selection and Seed Plot Technology to increase seed potato availability

Basic Seed Clean Land

Issue
- Low volumes of basic seed for bulking; unavailability of pathogen-free land for seed multiplication

Key Recommendations:
- Reform law to allow for increased private sector basic seed production
- Use university and ADC farms for seed multiplication

Quality Declared Seed

Issue
- Not recognized by MOALF and KEPHIS

Key Recommendations:
- Recognition of QDS by MOALF and KEPHIS
- Establishment of standards and guidelines on QDS
- Build capacity of farmers on how to effectively produce and use QDS. It will also need support to ensure the standards are observed. See page 5 for details

Seed Certification

Issue
- Costly inspection and labelling

Key Recommendations:
- Reduce the inspection costs per ha
- Limit labelling of seed classes to tradeable seed only, i.e. above C3 class
- Adopt digital seed inspection and certification schemes
- Harmonize with COMESA best practices, i.e. use NPT data from one season for a or the new variety testing and certification; reform law to support. *See page 2 for details*

Issue
- Low numbers and capacity of seed inspectors

Key Recommendations:
- Reform policy to allow private seed certification and support private testing laboratories
- KEPHIS to enhance seed inspection and pest risk assessment capabilities for imported seed potato. *See page 26 for details*

Seed Distribution

Issue
- Poor distribution channels and long distances between farmers and seed companies

Key Recommendations:
- Set up seed companies in production locations
- Expand decentralized seed multiplier systems to effectively reach farmers
- Explore and scale disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs
- Set up a PPP on seed storage with county governments, donors, and seed companies. *See page 6 for details*

Kenya's North Rift region is emerging as an important potato production region. Here, Samuel Sugut, a seed multiplier in his seed store in Nandi County, Kenya.

Credit: Hugh Rutherford (CIP)

KEY FINDINGS, PRIORITY ACTIONS AND INVESTMENTS

The seed potato industry study generated many useful recommendations with the focus on increasing the quality and availability of potato seed in Kenya. These recommendations are grouped into those impacting on importation, multiplication, certification and distribution. The sections below provide additional details, followed by the top five priority areas for action and investments.

IMPORTATION

- **Kenya should consider streamlining and shortening seed import inspection processes at the port of entry.** Kenya imports seed potato to meet a shortfall in seed quality available. The imported seed is of processing varieties, supplied mainly by Dutch, French, Scottish and Irish exporters. The exporter loads the seed potato tubers onto a ship which travels to the port of Mombasa. At the port of Mombasa, KEPHIS inspectors sample the seed once the container is offloaded. On visual inspection, seed samples are taken to KEPHIS laboratories in Nairobi or Muguga for further quality tests. The seed that is suspected of containing harmful pathogens is planted in a quarantine field for 3 – 4 months. The laboratory tests take 14 days. If the seed fails the laboratory test or quarantine field test, then the entire imported seed lot is destroyed. In all this time (whether 14 days or 3-4 months), the seed importer cannot trade in the seed, and the seed undergoes quality deterioration. Industry stakeholders recommend that KEPHIS should streamline the seed import inspection process and fast track it, to release results in near-real time to facilitate trade.
- **Kenya should consider applying a risk-based seed importation policy for potato.** Kenya does not have baseline data on existing pests and diseases of global significance and this creates challenges in instituting zero-tolerance standards to prevent the introduction of these pests and diseases through imports. Industry stakeholders recommend that KEPHIS should consider applying a risk-based import policy for seed potato once the data from a pilot pest risk analysis confirms prevalence of critical potato pests and diseases. This data will inform the revision of the quarantine pest and diseases list.

  The pilot pest risk assessment is undertaken jointly with KEPHIS and CABI in two counties; mainly for pest cyst nematode and bacterial wilt.
- **Kenya, like Egypt, has an opportunity to collaborate with the European Union scientific and technical counterparts in strengthening its pest risk assessment capabilities through sharing of technical data, joint pest risk assessments and extensive field-based research in Kenya to determine the performance of major pests (known and unknown) in Kenya's agro-ecologies.** Egypt, like Kenya, imports seed potato from the EU and has built a robust potato industry; with ware exports to Europe. Egypt succeeded in developing a robust program for the management of bacterial wilt (brown rot) through a technical collaboration with EU scientific, technical and seed exporter communities.
- **Egypt's pre-shipment seed potato inspection and certification offers a benchmarking opportunity for increasing traceability and quality.** Egypt has a system of double inspection (in both Egypt and the exporting EU country) involving designated Egyptian seed potato inspectors visiting seed production farms, packhouses and ports to certify the seed as meeting Egypt's import standards before the seed leaving the EU. On arrival in Egypt, the seed is sampled, analyzed and evaluated for compliance. If Kenya was to adopt this system then there would be increased assurance in the seed potato quality based on scientifically backed traceability of the seed imports right from the field to the packhouse and port.
- **Kenya should incentivize importation of tissue culture material for multiplication.** It is easier to meet infection-free standards for material produced from tissue culture, i.e. minitubers, than it is for tubers; since the soil-less production process ensures that

soilborne pathogens are absent. The government should provide tax rebates to incentivize seed importers to use minitubers to ramp up availability of seed potato and support initiatives in increasing access to blended finance for seed companies using the imported minitubers starter seed to meet the initial capital outlays.

MULTIPLICATION

- **Seed potato production from tissue culture[1] is a promising innovation with the potential to rapidly reduce the time for seed multiplication and enhance diseases control.** The use of mini-tubers and apical cuttings are being promoted in Kenya by CIP, KEPHIS and the Dutch government to increase the availability of seed potato. For instance, Kisima Farm piloted the use of cuttings to introduce ware potato farmers in Meru to quality propagation material. KEPHIS is working with KALRO and the government to increase multiplication of seed potato through aeroponics at the National Youth Service (NYS) Tumaini Farm in Nyandarua County. Industry stakeholders recommend sublicensing of imported varieties for multiplication to produce apical cuttings that can dramatically increase the availability of seed of high-value processing varieties currently imported.
- **Encourage government collaboration with the private sector in the production of Early Generation Seed (EGS) like in South Africa, to increase availability of seed potato of processing varieties.** Kenya imports ware potato of in-demand processing varieties from Egypt and South Africa, yet these could be grown locally by Kenyan farmers. Only 5% of varieties from KALRO and KEPHIS are suitable for processing, yet KALRO does not have the capacity to multiply enough seed of these top varieties, even when operating at full capacity. The private sector can effectively fill this gap through leveraging financial, research and development capabilities. In Kenya, a pilot funded by USAID on increasing availability of EGS succeeded in crowding in the private sector to create a 10-fold increase in the availability of EGS from 80 tons to 850 tons. Similarly, minituber production was increased from 30,000 to 1,000, 000 minitubers in 3.5 years. KALRO is working on EGS public-private partnerships that can be scaled to increase the availability of seed potato. In South Africa and Zambia, the private sector produces EGS. If the government were to revise its laws, and allow the private sector to produce EGS on the available public land; this would significantly increase seed potato availability.
- **Kenya can benchmark with Egypt and Japan in use of 'Pest Free Areas' for seed potato production.** One of the main challenges to seed potato availability in Kenya is the lack of clean, pest-free land for seed multiplication since potato requires a 5-year rotation period. Designated pest-free areas can increase availability of seed potato, especially to combat effect of bacterial wilt and potato cyst nematode (PCN) infestation in the main seed potato producing areas. These two pathogens can persist in soil for up to 30 years, reducing yields by up to 100% and are largely responsible for reduced yields in central and eastern Kenya, where potato has been produced often without crop rotation. Japan uses pest-free isolated production fields surrounded by "shelterbelts" while Egypt uses designated Pest Free Areas (PFAs) developed in collaboration with the EU, according to the United National Commission for Europe (UNECE) guidelines for pest-free areas. In Japan, "shelterbelts" are treated to prevent the entry of aphids and other flying insects that can transmit viral diseases. Egypt uses these PFAs for both seed potato multiplication and ware production. Agricultural universities and the Agricultural Development Corporation (ADC) land can be converted into seed potato production zones.
- **Promoting decentralized seed multiplication by clusters of farmer groups can increase uptake of quality seed potato.** In Kenya, through USAID funding, CIP is supporting clustering of seed potato multiplication in key potato producing regions in Kenya and this has been successful in increasing availability of seed potato and boosting yields of ware

[1] Plant tissue culture involves removing a vegetative part of a plant and growing it in the laboratory for multiplication. It offers alternative methods of propagation by in vitro techniques that provide production and multiplication of material with high quality and disease-free status. From tissue culture, techniques such as aeroponics, hydroponics and apical cuttings can yield seed potato.

potato. According to stakeholder feedback, Ethiopia is effectively using this model of seed multiplication; and Kenya too, can scale this across the country. Private seed companies could contract farmer groups organized into seed multiplying business units, to produce seed on their behalf and work with county governments to enforce the seed production contracts.

CERTIFICATION

- **C2 limit for multiplication (based on disease threshold) increases the ultimate unit cost of seed.** Until mid-2018, KEPHIS had imposed a limit for multiplication on the second certified seed class or C2; since the higher the seed class. The higher the vulnerability to pest and disease attack. Through the National Potato Council of Kenya, seed companies successfully lobbied for this to be increased to C3. KEPHIS recently raised the multiplication threshold to C3 allowing seed potato companies to bulk enough seed potato (both tubers and cuttings) for commercial viability, provided they can manage pests and diseases effectively. Stakeholders recommend that KEPHIS should accommodate this C3 certification limit on a long-term basis since seed classes below C3 moving within the same seed farm do not pose any biosecurity threat. Certifying seed class C1 and C2 on the same farm where they will be used to produce C3 seed only serves to increase seed multiplication costs ultimately passed on to ware potato farmers.
- **Reviewing the certification policy to allow for private certification can increase the availability of seed potato by improving Kenya's capacity to effectively meet the industry's demands for seed certification: KEPHIS has already developed a framework for accreditation of private seed inspectors to address its understaffing challenges.** It is also rolling out a comprehensive training program, and authorization of the qualified private seed inspectors are commendable though requires further investments. So far 28 inspectors from private seed companies and county governments have been trained and authorized. The private seed inspectors are bound by KEPHIS regulations and are subject to revocation of seed inspection authority if any violation is committed. Kenya would do well to draw lessons from Zambia where private certification has been extensively implemented. In Zambia, private inspectors are held to the minimum qualifications as government seed inspectors, i.e. should have a minimum of a diploma in seed certification.
- **KEPHIS should lower National Performance Trials' costs and timelines; currently at $3,563 for two seasons.** Recommendations include using data for only one season, and also considering trial data from varieties registered in 2 COMESA or SADC countries. In South Africa, the variety testing and release processes on seed potato include only Distinctiveness, Uniformity, and Stability (DUS) and not Value for Cultivation and Use (VCU) data, provided the variety meets the DUS criteria. This shortens the process and eliminates additional costs. As highlighted earlier, there is an opportunity for private seed certification and inspection by KEPHIS to ease the backlog of seed inspection demands by seed companies. This model works very effectively in South Africa and Zambia, where it supports training and certification of seed inspectors; and regular auditing of both private inspectors and laboratories for continued compliance.

DISTRIBUTION

- **Kenya should explore and scale disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs. Seed potato mini-tubers are bulky; seed producers are mainly located long distances from ware potato growing zones.** This situation contributes significantly to transportation costs and the overall cost of using certified seed potato material; thereby further lowering farmers' incentives to use certified seed potato each season. Digital technologies offer opportunities to explore and scale disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs. These innovations will contribute significantly to increasing both affordability and accessibility (see below for more details).

- **Considerable investments in mechanization, irrigation and storage infrastructure are critical for attaining year-round seed potato production to increase seed availability.** Research by TNS and stakeholder engagement confirm that year-round seed availability could mitigate seed price volatility. Promoting Dutch - or Irish origin varieties with higher yields and longer dormancy may considerably increase demand from ware potato farmers and justify storage investments. Another promising venture is the co-financing of storage warehouses in potato growing counties through public-private partnerships involving farmers, county governments and development partners.

PRIORITY INVESTMENTS AND POLICY ACTIONS TO CREATE A STEP-CHANGE IN SEED POTATO AVAILABILITY IN KENYA

Based on the analysis of Kenya's seed potato value chain, five priority areas are identified for investment and policy reform action to create a step change in the availability of seed potato from both production and importation. These value proposition outline immediate -, medium - and long-term horizons.

a. Support production and use of apical cuttings as seed potato

Production of seed from apical cuttings by seed potato companies offers a two-fold increase in yield over the use of mini-tubers. Not only are they cheaper per unit but also reduce susceptibility to and proliferation of seed potato pests and diseases. This offers a promising route for accelerated seed potato production. A major drawback is the need for plenty of water for irrigation during propagation as the plantlets are very fragile. Seed from apical cuttings can be further multiplied for two more generations – meaning that the seed that farmers buy is equivalent to basic or certified third generation (C1) seed and will produce high yielding crops without risk of significant seed degeneration and loss of yield potential.

Increasing investments in apical cutting production over the medium to long term will increase the availability of quality seed potato and contribute to reducing the annual seed potato gap in demand of more than 300,000 tons. KEPHIS has developed certification guidelines for apical cuttings and is working with the government and private sector to increase the availability of apical cuttings for use by smallholder ware potato farmers. Apical cuttings offer farmers the opportunity to effectively and safely produce quality seed that they can use for one or two seasons, starting with clean, certified seed potato.

A basic comparator analysis of cuttings to mini-tubers is contained in Table 1 below.

Assuming the cost of production per year of $ 1.5 million for a 100-ha farm[2], the use of cuttings would produce on average 45.7 million seed tubers, while for a similar cost, tubers would produce 30.8 million seed tubers. Cuttings yield 1.48 times more seed than tubers.

The bigger the seed potato farm, the higher the return but this will be dependent on other variables like soil health.

b. Reform policy to allow private seed certification and support private testing laboratories

Stakeholders blame KEPHIS for being slow in seed inspection and certification due to a persistent shortage of seed potato inspectors with adequate skills in high-speed, modern seed inspection techniques. KEPHIS inspectors cover the entire country with responsibility for more than 400 varieties of diverse crops. Efforts to enhance private inspection by KEPHIS are commendable. KEPHIS is rolling out a comprehensive training program and has trained and authorized 28 qualified private seed inspectors from private seed companies and county governments. KEPHIS through its Centre of Phytosanitary Excellence (COPE) should partner with agricultural universities, county governments in potato growing areas and private seed companies to identify agriculture graduates who can be trained in large numbers to reduce the seed inspector shortages. COPE already has a curriculum that covers all

[2] From TNS Analysis and Stakeholder Interviews: Costs of running a 100-ha farm per year put at KES 150 million (equivalent to $ 1.5 million; assuming an exchange rate of KES 100 = $ 1). Assumes these costs: $ 450,000 for 1000-ton cold storage; $ 1 million for tractors, irrigation & equipment; and $ 100,000 for packaging.

phytosanitary issues as well as seed certification. KEPHIS could enrol 100 plus students annually, take them through the training program with practical internships in seed companies, certify and authorize them to conduct inspection and certification across the country. These graduates can also be attached to private and county seed inspection and certification facilities, which would be inspected, audited and annually certified by KEPHIS and the International Seed Testing Association (ISTA). This would require an innovative PPP and policy advocacy to leverage investments, and to create the needed regulatory change to allow for extensive but KEPHIS/ISTA accredited private seed certification. These are short- to medium-term initiatives.

c. Reform policy to allow for collaboration in production of Early Generation Seed (EGS) by government and private seed companies

To ensure continuity of the gains made in creating a vibrant seed potato industry in Kenya, the government could collaborate with the private sector in production of Early Generation Seed (EGS). This would not only increase availability of foundation and breeder seed potato but would also ensure that seed companies produce varieties with farmer-demanded attributes. Currently, production of early generation seed is the sole mandate of the national research agency (Kenya Agricultural Research Organization (KALRO) that cannot produce the quantities of breeder and foundation seed required by the industry. Policy advocacy for reforming the current seed laws to recognize early generation seed production from the private sector is needed. Similarly, investments in KALRO should support the maintenance of public seed potato varieties where these have significant market demand, and support a PPP on EGS production for in-demand high-value varieties. Lessons from EGS pilots should be leveraged for scaling up an EGS PPP. The private sector should lead new variety development where it has a competitive edge.

d. Recognize Quality Declared Seed (QDS) system in Kenyan seed laws

A Quality Declared Seed (QDS) system is also known as a Quality Declared Planting Material (QDPM) system. QDS systems involve educating farmers and seed growers on quality seed standards to produce quality, clean disease-free planting material from registered varieties. A QDS system can complement certified seed systems in serving as a bridge between informal and formal seed systems. QDS systems facilitate affordable access to quality seed for smallholder farmers while serving as a basis for the creation of future certified seed demand. QDS is formally recognized by FAO and some national seed certification agencies in Africa. Ethiopia, Uganda, Tanzania and Zambia formally recognize the production, inspection and cultivation of QDS for potato. Generally, the production and marketing of QDS are limited to a specific jurisdiction, managed by local governments.

Investments and policy advocacy would be required in the immediate to medium term to support the line ministry, KEPHIS, county governments and smallholder farmers in the move towards QDS systems. KEPHIS would be supported in the development of guidelines and inspection capabilities, while county governments would be supported in enforcing the QDS jurisdiction. Private seed companies would sell the certified starting seed potato material to county governments or farmer producer organizations in these schemes.

e. Explore and scale disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs

Currently, the newly emerging ware potato production zones are geographically dispersed; with on average more than 400 kilometres to be covered to the nearest seed potato company, often located in another county. This situation has further impacted the lack of seed potato for ware farmers at the critical moments during planting seasons as seed is not available when and where required. The bulky nature of seed potato propagation materials coupled with the long distances to seed-producing farms, increase the cost of transportation and the overall cost of certified seed potato.

There are opportunities for exploring and scaling disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs. Existing Digital agritech solutions can be leveraged to simultaneously increase availability and reduce

transportation costs by facilitating the generation of geo-located bulk orders, and combining smart logistics to transport seed to farmers within specific localities. Currently, seed companies post their seed inventory on a members' only dashboard such as ViaziSoko (managed by National Potato Council of Kenya) and farmers who need seed can communicate directly via phone with the seed company. The seed company prepares the order and once ready the farmer is required to collect it immediately from the seed company's farm due to the highly perishable and bulky nature of seed tubers and cuttings. This represents complex logistics that can be mediated by agritech innovations.

The World Bank's Agriculture Global Practice is working with agritech innovators who can be involved in generating or scaling this solution. One such innovator is iProcure – a firm that is using data analytics to aggregate demand and last-mile distribution networks to enhance agricultural supply chains in rural Kenya. The Potato Council is also working with Viazi King - a logistics company to develop the digital platform that would leverage the power of data analytics and fintech for payments. These innovations could be explored for lessons on adaptation and scaling to reach the 800,000 ware potato farmers in Kenya.

INTRODUCTION

Potato is Kenya's second most important food crop, after maize in Kenya. Its productivity is impacted by low availability of certified seed, persistent use of older varieties, poor soil fertility, high pest and disease incidence, and low knowledge levels of good agricultural practices. Low yields result in low incomes in a vicious cycle for the country's potato farmers whereas high-yielding, adapted and newer varieties are available from imported seed potato stocks. Varieties with origins in France, Ireland, the Netherlands, and Scotland have a yield potential ranging from 40 - 100 tons per hectare, compared to the commonly cultivated varieties with a yield potential 16-20 tons per hectare under optimal conditions of irrigation, fertilizer use and pest and disease control. Compared to Egypt and South Africa, Kenya's potato industry lags, with these two countries having robust industries supported by high-yielding, highly demanded ware potato varieties suitable for both ware and processing. The average yield per hectare in Egypt is 25 tons, and 35 tons in South Africa, respectively. Indeed, Kenyan processors supplying frozen chips to high-end hospitality chains are importing ware potato from these two countries – locking out local farmers from this high-value industry.

To support the development of Kenya's potato industry, over the last ten years, the Kenyan government has entered into bilateral arrangements with the British, Dutch, Irish and French governments on importation of seed potato to increase the availability of certified seed and ultimately the farm-level yields of ware potato. More than 40 Dutch varieties have been introduced and adopted by seed companies in Kenya and have been tested for adaptability to local conditions. Similarly, French, Irish and Scottish varieties have been introduced and tested in Kenya. These bilateral arrangements have included technical capacity building components to increase the inspection and test capacity of the Kenya Plant Health Inspectorate Services (KEPHIS). Pests and diseases of global significance in seed potato trade pose a potential threat to potato industries the world over. They have to be mitigated by various sanitary and phytosanitary measures including quarantine and zero-tolerance. Kenya is not alone in this and has had a zero-tolerance policy in place for decades. Recent quality and plant health safety concerns over the importation and use of seed potato tubers have prompted industry stakeholders to explore the possibility of developing an evidence-based strategy for managing biosecurity risks while ensuring the long-term viability of Kenya's potato industry.

From this industry need, IFC conducted a diagnostic study of Kenya's seed potato industry to determine the issues impacting the availability of quality seed potato from importation and local production. The study undertook in-depth stakeholder interviews and desk reviews of relevant secondary data. The study findings were validated through stakeholders' workshop and further field-based stakeholder engagements. The diagnostic study highlights key issues, emerging opportunities, African and global best practices for benchmarking and makes recommendations for strategic priority policy reforms and investments.

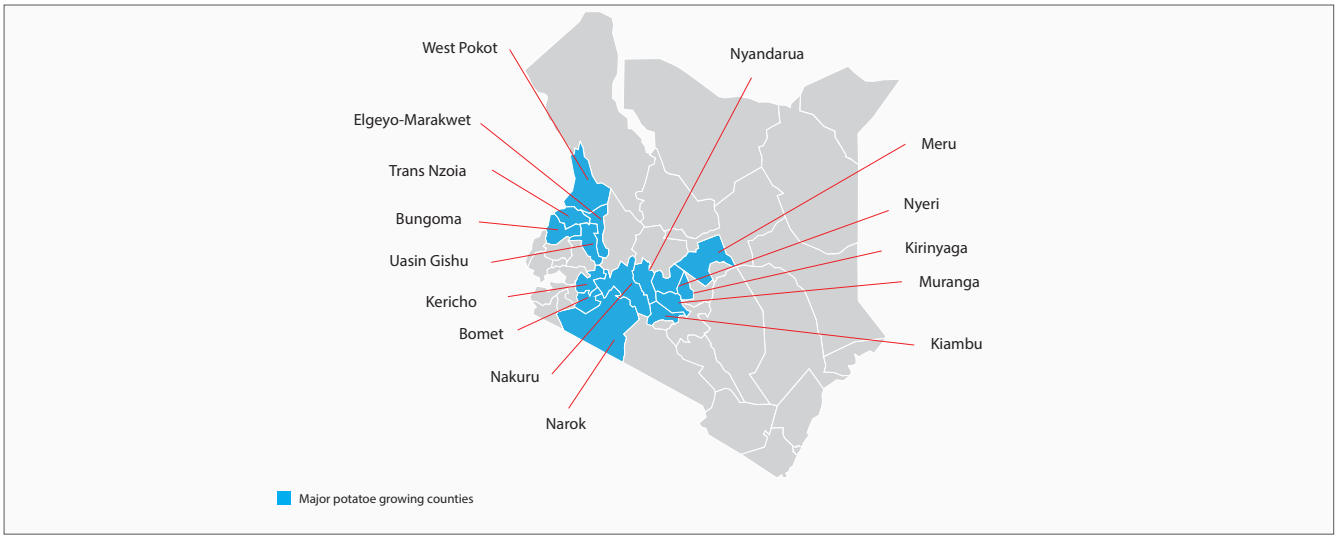
WITH RISING DEMAND FOR POTATO, THE KENYAN GOVERNMENT HAS PRIORITIZED IT AS AN IMPORTANT FOOD AND CASH CROP IN THE NATIONAL DEVELOPMENT BLUEPRINT, THE BIG 4 AGENDA.

1. The Potato Industry in Kenya

OVERVIEW OF THE POTATO INDUSTRY IN KENYA

Potato is the second most important food in Kenya after maize and third globally, after rice and wheat (Devaux et al., 2014). It has a high-value per unit area of land and thrives in mid- to high altitude regions, with a short cropping cycle of 3 - 4 months; allowing for two production seasons per year under rain-fed systems. Harvestable tubers are available 60 days after the onset of the rainy season – a significant advantage over grains, which typically require 6 - 9 months. Potato is a low-cost but nutritionally rich staple food for the rapidly urbanizing population: contributing protein, vitamin C, B vitamins, zinc and iron to the diet. With a rising demand for potato, the Kenyan government has prioritized it as an important food and cash crop in the national development blueprint, the Big 4 Agenda. Increasing potato productivity is core to the Food and Nutrition Security Pillar of the Big 4 Agenda. Employing 2 million people, and grown by 800,000 farmers, the potato sub-sector contributes $ 500 million per year to Kenya's economy. The main potato growing counties include: Nakuru, Nyandarua, Kiambu and Meru counties with newly emerging potato growing counties being Bomet, Narok and Bungoma (see map below).

Figure 1: Major Potato Producing Counties Source: TechnoServe (TNS) Analysis



In Kenya, total potato volumes are far below the national 2022 target of 2.5 million tons per year, with 2017 data indicating that the country produced 1.5 million tons. Average yields per farmer are 6 - 10 tons per hectare under rain-fed conditions, yet robust Kenyan varieties can triple or quadruple this 30 - 40 tons per hectare per year. Dutch, French, Irish and Scottish varieties can yield as much as 60 tons per hectare under optimal irrigation, fertilizer and spray regimes.

Challenges in raising average farm yields and consequently, the national volumes include: small farm sizes (less than 2 hectares), repeated cultivation of potato without crop rotation, use of farm-saved or low-quality seed sourced informally, high pest and disease build-up on farms, inadequate knowledge of good agricultural practices and low levels of mechanization. To address these challenges, the government, donors and the private sector have rolled out initiatives to increase the availability of quality seed of high-yielding, disease-tolerant varieties to farmers. These efforts have focused on the introduction of new varieties, breeding, seed multiplication, innovative seed distribution strategies the such as use of village-based suppliers, and investments in seed storage.

Varieties grown in Kenya include Shangi, Dutch Robijn, Asante, Sherekea, Purple Gold, Kenya Mpya, Arnova, Connect, Rudolph, Sarpo Mira and others. Shangi, by far is the most dominant variety due to yield, market demand, seed availability and cooking qualities. Popular processing varieties include Markies, Manitou, Jelly, Dutch Robijn and Destiny.

It is worth noting that potato required for processing by high-end hotel and restaurant businesses is imported from Egypt and South Africa. Though there have been efforts to ramp up local production of the highly demanded processing varieties, the volumes produced do not meet demand since these varieties have not been widely adopted by farmers, they require intensive agronomic practices and there is not enough planting material available. The government – through the Ministry of Agriculture and KEPHIS – is working together with other stakeholders to increase the supply of quality seed of these varieties.

There is a shortage of clean potato seed in Kenya and farmers depend on informal seed sources which include farm-saved (self-supply), local markets or neighbours. Due to limited supply, the certified potato seeds are highly-priced (Ayieko & Tschirley, 2006). The informal system leads to the use of poor quality seeds which often accelerates the spread of seed-borne diseases (Kinyua et al., 2001; Ng'ang'a et al., 2003).

THE SEED POTATO INDUSTRY IN KENYA

Kenya's annual seed potato demand is 320,000 tons against production of 6,700 tons[3]. Therefore, low accessibility and availability of certified seed potato is the most critical bottleneck in raising ware potato productivity in Kenya.

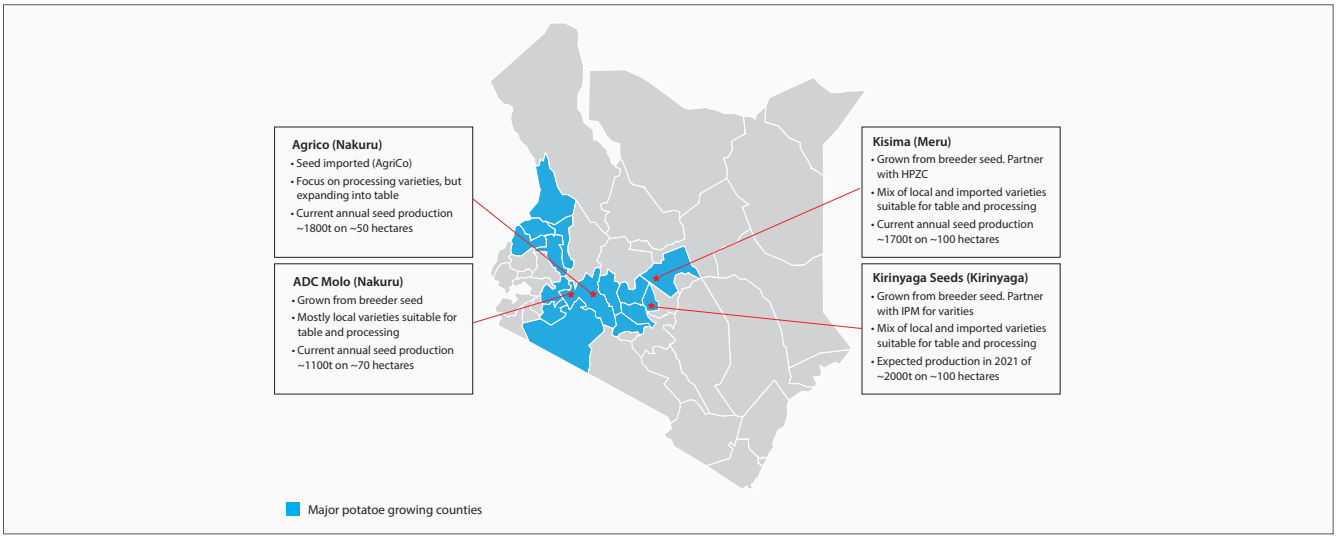
As seen in Figure 1, 15 counties produce ware potato but as Figure 2 shows, the major seed potato companies are located in Kirinyaga, Meru, and Nakuru counties. This implies that farmers in Bomet, Bungoma, Kericho, Kirinyaga, Narok, Trans Nzoia and West Pokot have to travel over long distances to other counties to purchase certified seed potato directly from these companies, as there are no satellite distribution centres or licensed resale agents for seed potato, as there are in cereal or grain crops.

Farmers have resorted to using uncertified planting materials: farm-saved, from neighbours or local markets. This has resulted in the proliferation of diseases, mainly bacterial wilt, viral diseases and nematodes – further decreasing potential yields, and incomes from ware potato.

There are two main seed production systems in Kenya: formal (legally recognized) and informal (not legally recognized). Formal seed undergoes seed certification by KEPHIS, following Kenyan laws, and involves KALRO, KEPHIS and certified seed growers. Conversely, the informal seed system comprises all activities producing seed outside the legal system.

[3] Analysis by CIP. Assuming 160,000 hectares and planting rates of 2 tons per hectare.

Figure 2: Location of Seed Potato Companies



Source: TNS Analysis

Recognizing that farmers need to be gradually moved from informal to formal seed systems, various initiatives over the years have sought to improve the quality of seed produced outside of the formal seed system. These initiatives are driven mainly by the International Potato Center (CIP), donors, the Kenyan government and non-profit organizations. For instance, CIP pioneered the production of seed by farmers through positive seed selection - where farmers train on how to select the best plants in the field, to keep as seed for use on their farms in subsequent seasons. It is worth noting that new varieties of seed potato are approved for commercialization only after undergoing tests related to their adaptability and suitability for cultivation under the growing conditions in Kenya. These are the national performance trials (NPTs).

The formal seed industry in Kenya currently comprises of 19 seed companies (see Annex 1) who either produce certified seed potato from basic seed obtained from KALRO or import and multiply pre-basic seed. Pre-basic and basic seed are the starting materials for certified seed production.

Over the last ten years, the Kenyan government has set up various initiatives and partnerships aimed at increasing the availability of certified seed potato. These include bilateral agreements with the Dutch, French and British governments to avail modern, high-yielding, and in-demand varieties to boost local efforts in breeding, multiplying and commercializing these varieties. Through these initiatives, more than 40 new Dutch varieties have been introduced into the country while Irish varieties include: Fandango, Tornado and Imagine (imported in 2019). It is estimated that the average production per hectare of the Irish varieties is 120 tons while the Dutch varieties can average 60 tons per hectare. These are varieties with promising potential for curbing Kenya's seed shortage of more than 300,000 tons per year (Maina, 2019).

Agrico East Africa is the leading seed potato importer in Kenya; importing varieties such as Markies, Manitou, Jelly, Rudolf and Manitou.

There are currently two supply systems of certified seed produced in the formal system in Kenya. These supply systems are:

- Production of certified seed starting from mini-tubers or healthy mother plants produced in Kenya
- Production of certified seed through the multiplication of imported seed (e.g. from the Netherlands, Scotland, Ireland or France).

In the second system, pre-basic and basic seed is produced in the Netherlands, Scotland, Ireland or France by specialized seed growers guided by strict European Union and national seed certification rules and regulations. Basic seed (usually class E or SE) is then exported to Kenya by private seed companies based on an import permit issued by KEPHIS. The basic seed is further multiplied in Kenya into certified seed classes following KEPHIS regulations and certification standards.

Credit: International Potato Center (CIP)

2. Seed Potato Multiplication and Certification in Kenya

MODELS OF SEED POTATO MULTIPLICATION

Kenya's formal seed industry is governed and regulated by the Seeds and Plant Varieties Act (Cap 326) of 2012 which recognizes breeders, pre-basic, basic and certified seed classes (see page 14 for details on these seed classes). KEPHIS registers all seed multipliers operating in Kenya.

The formal sources of seed potato in Kenya are public institutions (KALRO and ADC), private seed companies and registered individual seed growers (see Annex 1). Such seed must have undergone certification by KEPHIS.

In Kenya, there are three main types of formal seed systems:

- **Public formal seed system**: Here, the public sector undertakes all activities involved in seed development through to marketing. For example, KALRO carries out breeding and seed production of new varieties, multiplication and distribution. KEPHIS supervises seed multiplication.
- **Public-private formal seed system**: This involves the participation of the public and private sector from variety development through to marketing. KALRO conducts the research and breeding while the private sector multiplies the seed under the supervision of KEPHIS and distributes the seed to farmers.
- **Closed value chains or fully private formal seed system**: These are systems that are entirely controlled by the private sector from breeding and variety development to seed multiplication and distribution. There is minimal government involvement except in seed quality control and certification (KEPHIS). This system is applied by private companies including Agrico E.A. Ltd, and Kisima Farm Ltd in close cooperation with their partners in the Netherlands. Similar systems are employed by companies multiplying and distributing varieties with French, Irish and Scottish origins.

There are three main business models for producing seed:

- **From breeder seed**: Licensed local or international companies grow seed from mini-tubers through to the second stage of certification, known as the C2. Kisima, ADC, and Kirinyaga Seeds use the breeder seed model and mix up local and imported varieties suitable for table use and processing.

- **Buy basic seed**: Agrico East Africa uses the direct seed potato tuber importation model for further multiplication, with their main focus being on processing varieties.
- **Clean seed multiplication**: Seeds are purchased from certified producers before they are multiplied on a local scale.

Seed multiplication requires large amounts of disease-free land to allow for 4-year crop rotations (minimum 200 hectares) to reduce the accumulation of pests and diseases. Pests and diseases are a major challenge to potato growers across the world. Tried and tested methods of producing relatively disease-free propagation materials include the use of tissue culture (aeroponics and hydroponics), positive seed selection and seed plot technology. Tissue culture has a two-fold yield gain potential over seed tubers; while the two latter techniques can be used at ware potato farmer level to meet on-farm seed tuber demand by producing 'clean' seed starting with certified seed potato.

The seed potato production system starts with completely virus-free plantlets produced from tubers or tissue culture. In the case of tissue culture, these plantlets are planted in an insect-proof screen house to produce clean propagation material. The seed resulting from this process is called starter seed potato. The starter seed potato is further multiplied as cuttings or mini-tubers by KALRO, ADC Farm, commercial seed potato companies and potato grower organizations (see below for details on the use of apical cuttings and mini-tubers; and Annex 2 for details on the use of hydroponics, aeroponics, positive seed selection and seed plot technology).

Apical Cuttings

Apical cuttings are transplants produced from tissue culture plantlets in which the mother plant is maintained in a juvenile state throughout the production cycle. The mother plants are produced from shoots produced by the initial tissue culture plantlet and subsequent cuttings until 3-4 weeks when the first lot of cuttings is to be transplanted in the field. Once rooted, the cuttings can then be transplanted into the field for seed tuber production. The high potential in productivity can be attributed to the physiologically young tissue retained at the simple leaf stage which results in high productivity per apical cutting in the field: 10-15+ tubers per cutting — compared to 6-8 from seed potato tubers (Parker, 2019). The resulting tubers are multiplied for a further season or two, and then harvested for on-farm use or sold as seed.

If successfully applied, using cuttings can reduce cost per hectare of sellable seed by approximately $ 300; further increasing affordability and accessibility of quality propagation material.

KEPHIS has approved apical cuttings as seed potato propagation materials.

Mini-tubers

Mini-tubers are produced from tissue culture plantlets but unlike apical cuttings, tissue culture plantlets have to mature and produce mini-tubers.

Table 1: Classification system of seed potato produced in Kenya

Type of material	Seed class	Generation (maximum)
Healthy mother plants (clonal selection) in-vitro plants, mini-tubers	Breeders seed	G0
Tubers	Pre-basic	G1
Tubers	Basic	G2
Tubers	Certified 1	G3
Tubers	Certified 2	G4
Tubers	Certified 3	G5

Source: CAP 326 i.e. Seed and Plant Varieties Act of 2012

Table 2: Classification system of seed potato imported from the Netherlands and multiplied in Kenya

Type of material	Seed class	Generation (maximum)	Location of production
Healthy mother plants (clonal selection) in-vitro plants, mini-tubers	Breeders seed	G0	Netherlands
Tubers	Pre-basic 1	G1	Netherlands
Tubers	Pre-basic 2	G2	Netherlands
Tubers	Pre-basic 3	G3	Netherlands
Tubers	Pre-basic 4	G4	Netherlands
Tubers	S (basic 1)	G5	Netherlands
Tubers	SE (basic 2)	G6	Netherlands
Tubers	E (basic 3)	G7	Netherlands
Tubers	Certified 1	G8	Kenya
Tubers	Certified 2	G9	Kenya
Tubers	Certified 3	G10	Kenya

Source: KEPHIS and Dutch General Inspection Service (NAK)

Mini-tubers can be produced under soil-less cultivation systems, i.e. aeroponic and hydroponic setups, to increase the availability of pathogen-free seed potatoes. (Bisognin, Bandinelli, Kielse, & Fischer, 2015).

Both of these seed production systems would require a minimum capital outlay of $ 1.5 million, for a 100-hectare farm with irrigation, mechanization and cold seed stores (TNS Analysis).

Figure 3: Production of Seed Potato from Aeroponics and Hydroponics Systems

Picture 1. Depicting minituber production in aeroponics system
(Courtesy of KALRO Tigoni)

Picture 2. Depicting minituber production in a hydroponics system
(Courtesy of ADC Sirikwa farm)

Picture 3. Depicting minituber production of variety Asante in an aeroponics system
(Courtesy of ADC Sirikwa farm)

Table 3: Comparative analysis for seed potato production using cuttings and seed tubers

	Cuttings	Seed tubers
Cost /Unit ($)	0.10	0.15
Spacing (m)	(0.30 x 0.75)	(0.30 x 0.75)
Units/Ha (seed required)	44,000	44,000
Yield/unit	7 to 15	6 to 8
Yield (seed produced)/Ha (1000')	308 – 606	264 – 352

Source: IFC Analysis, 2019

The table below summarizes the business opportunity for the use of apical cuttings as propagation material.

Assuming the cost of production per year of $ 1.5 million for a 100-ha farm[4], the use of cuttings would produce on average 45.7 million seed tubers, while for a similar cost, tubers would produce 30.8 million seed tubers. Cuttings yield 1.48 times more seed than tubers. The bigger the seed potato farm, the higher the return, but this will be dependent on other variables like soil health.

SEED POTATO MULTIPLICATION AND CERTIFICATION CHALLENGES

Previous analysis and stakeholder interviews highlight various seed potato multiplication and certification challenges, as summarized below.

- **Seed potato requires vegetative propagation methods is bulky and prone to attacks by pests and diseases, which compromises seed quality.** In the use of cuttings, investments in irrigation are required since cuttings have high water requirements. Most ware potato production is rain-fed with farmers targeting the March -June, and September -December planting seasons. With effects of climate change decreasing rainfall certainty, seed companies need to invest in irrigation to ensure seed potato productivity and to take advantage of seed market opportunities during the main planting seasons. Investments in storage are also vital.
- **Seed potato production processes are fairly long.** The duration from multiplication to commercial seed production to certification is a minimum of 27 months. In the process, there may be changes in the demand from smallholder farmers, rendering the investments in seed production null. Stakeholders advocate for data from 3 seasons (9 months) to be considered as adequate.
- **Smallholder farmers recycle seed potato from season to season.** Their incentive to use certified seed each season is low; compared to maize farmers who can only reuse the hybrid seed for one season with yield penalties. Establishing and running a seed potato farms are capital intensive, and there is a lack of finance to support seed potato entrepreneurs, who must deal with this scenario.
- **There is limited disease-free land available for large-scale seed multiplication.** Land in the main potato growing areas, especially in Kirinyanga, Nyandarua, and Meru has been used for ware potato production for decades, with low crop rotation, repeated use of farm-saved seed and poor agronomic practices that have led to the accumulation of Potato Cyst Nematode (PCN) and bacterial wilt pathogens - two of the most serious pathogens in potato production. To be effective, seed potato production should be done in 'clean' or 'virgin' land - on which potato or related crops have not been grown previously to reduce the incidences of pests and diseases that can destroy between 30-100% of the seed potato crop.
- **Large-scale certified seed multiplication requires large farms and high levels of investment.** For optimal seed potato multiplication operations,

[4] From TNS Analysis and Stakeholder Interviews: Costs of running a 100-ha farm per year put at KES 150 million (equivalent to $ 1.5 million; assuming an exchange rate of KES 100 = $ 1). Assumes these costs: $ 450,000 for 1000-ton cold storage; $ 1 million for tractors, irrigation & equipment; and $ 100,000 for packaging.

a minimum of 200 hectares[5] of land for cropping is needed, together with associated investments in irrigation, production, mechanization, certification, packing and storage. For tissue culture-derived seed potato production models, seed companies will generate revenue after two years. A major challenge cited by seed companies is that they cannot currently get access to adequate financing for investments and operations.

- **C2 limit for multiplication (based on disease threshold) increases the unit cost of seed.** Until mid-2018, KEPHIS had imposed a limit for multiplication on the second certified seed class or C2; since the higher the seed class the higher the vulnerability to pest and disease attack. Through the National Potato Council of Kenya, seed companies successfully lobbied for this to be increased to C3. KEPHIS recently raised the multiplication threshold to C3. This allows seed potato companies to bulk enough seed potato (both tubers and cuttings) for commercial viability, provided they can manage pests and diseases effectively. Stakeholders recommend that KEPHIS should accommodate this C3 certification limit on a longer-term basis since seed classes below C3 moving only within the seed farm do not pose any biosecurity threat. Certifying seed class C1 and C2 that is used to produce C3 class of seed on the same farm only serves to increase seed multiplication costs which are ultimately passed on to ware potato farmers.

EMERGING OPPORTUNITIES, BEST PRACTICES AND TRENDS IN SEED MULTIPLICATION AND CERTIFICATION

Irrigation: This is a potential area for investment in the seed potato industry. Irrigation would help to ensure year-round production of seed potato. Of concern, however, is the availability of irrigation water sources close to seed production farms, and the need for farmer training on how to optimize irrigation. Furthermore, the water quality of the irrigation should be high to ensure that the water does not introduce pathogens to the seed potato during cropping. Seed potato production can be expanded into new regions using irrigation.

Mechanization: Mechanization can be employed in cultivation, fertigation and harvesting. It reduces human traffic in the seed potato farm, thereby setting up the farm as a quarantine seed multiplication area - with reduced incidences of seed contamination. Mechanization improves tuber quality by sorting to get the right tuber sizes, minimizing cuts and bruises which increase susceptibility to postharvest pathogen infestation in seed potato.

Pest Free Areas (PFAs): Sanitary and phytosanitary (SPS) control is especially important in seed potato multiplication considering the high susceptibility of potato to pests and diseases. In Japan, the National Center for Seeds and Seedlings (NCSS) produces and distributes disease-free and high quality basic (foundation) seed. It strictly manages the seed potato production in isolated fields surrounded by 'shelterbelts' designed and treated to prevent the entry of aphids and other flying insects that can transmit viral diseases. This is complemented by a 5-year crop rotation. In Egypt, the country through EU support developed Pest Free Areas that were systematically managed to prevent contamination with pathogens especially the Pest Cyst Nematode (PCN) and bacteria responsible for Potato Brown Rot and Bacterial Wilt. These were developed according to the United National Commission for Europe (UNECE) guidelines for pest-free areas (see box 2 and 3S for details). Egypt uses these PFAs for both seed potato multiplication and ware production.

Private Certification: KEPHIS has already developed a framework for accreditation of private seed inspectors to address its understaffing challenges. KEPHIS is rolling out a comprehensive training program and has so far trained and authorized 28 inspectors from private seed companies and county governments. These private seed inspectors are bound by KEPHIS regulations and are subject to revocation of seed inspection authority if any violation is committed. This is a commendable move and requires further investments.

[5] Assumes production on 50 hectares and a 4-year rotation cycle, as recommended for managing pests and disease infestation.

Kenya would do well to draw lessons from Zambia where private certification has been extensively implemented. In Zambia, private inspectors are held to the minimum qualifications as government seed inspectors. Zambia's Seed Control and Certification Institute (SCCI) offers a diploma training course, a pre-requisite for accreditation as a private inspector (Kuhlmann, Zhou, & Keating, 2019).

KEPHIS through its Centre of Phytosanitary Excellence (COPE) should partner with agricultural universities, county governments in potato growing areas and private seed companies to identify agriculture graduates who can be trained in large numbers to reduce the seed inspector shortages. COPE already has a curriculum that covers all phytosanitary issues as well as seed certification. COPE also runs a seed potato production course for seed company staff and individuals. KEPHIS could enrol 100 plus students annually, take them through the two training programs with practical internships in seed companies, certify and authorize them to conduct inspection and certification across the country. These graduates can also be attached to private and county seed inspection and certification facilities, which would be inspected, audited and annually certified by KEPHIS and ISTA. This would require an innovative PPP and policy advocacy to leverage investments, and to create the needed regulatory change to allow for extensive but KEPHIS/ISTA accredited private seed certification.

Quality Declared Seed (QDS): A Quality Declared Seed (QDS) system also known as a Quality Declared Planting Material (QDPM) system is a quality assurance scheme for seed production that is less demanding in comparison to the standard quality control systems. It is formally recognized by FAO and some national seed certification agencies in Africa. QDS systems allow for less rigorous and low-cost inspection regimes while producing quality, clean disease-free planting material from registered varieties. QDS systems serve as a bridge for formal seed producers – facilitating access to quality seed for smallholder farmers while serving as a basis for creation of future certified seed demand. Generally, the production and marketing of QDS are limited to a specific jurisdiction, managed by local governments.

QDS quality standards are defined by the regulatory authority. Several COMESA region countries including Ethiopia, Rwanda, Uganda, Tanzania and Zambia formally recognize the production, inspection and cultivation of QDS for potato seed. Investments and policy advocacy would be required in the immediate to medium term to support the line ministry, KEPHIS, county governments and smallholder farmers in the move towards QDS systems. KEPHIS would be supported in the development of guidelines and inspection capabilities, while county governments would be supported in enforcing the QDS jurisdiction. Private seed companies would sell the certified starting seed potato material to county governments or farmer producer organizations in these schemes.

The OECD and FAO have stressed the importance of QDS seed as a way to help transition farmers from the informal sector to the formal sector and ensure that the resulting seed from QDS systems is of satisfactory quality (Kuhlmann, Zhou, & Keating, 2019).

In Ethiopia, the piloting of the concept encompassed intensive awareness creation and training, preparation of the guidelines, and labeling of the Quality Declared Planting Materials (QDPM) seed for traceability and enhanced credibility. The producers' contact details were imprinted on labels to facilitate queries by seed buyers. Seed movement was limited to select zones unless it was subjected to formal certification. Positive feedback from the pilot phase highlighted QDPM as an essential tool for quality assurance and control among the cooperative members in affirming constant quality seed production. Farmers were able to recognize the differences in seed quality between farm-saved and QDS seed. The QDS (and QDPM) concept was officially recognized in February 2014 and updated in the Ethiopian Seed Proclamation No 782/2013, but guidelines were yet to be developed by then (FAO, 2015). In Tanzania, the production and use of QDS is localized to the ward level. The seed regulator involves the local government authorities, extension agents and non-profits in building capacity of farmers in seed production and in policing non-commercial use of QDS seed within the specified jurisdiction.

Royalties: Royalties are an integral part of seed costs and represent a return on investment for breeders. Breeders like KALRO need the money to maintain existing varieties and develop new ones. To keep overall seed costs low, a dynamic and innovative mechanism of collection of royalty fees is needed. Stakeholder interviews unearthed several proposals. One proposal from seed companies is for the government to pay royalty fees to breeders to ensure smallholder farmers on less than 10 hectares do not pay royalties; this can reduce seed prices by as much as 30%. Another one suggests that royalties be paid as a one-off fee during licensing as opposed to the current annual arrangement of 2.5 % of overall seed sales. Stakeholders are also pushing for KALRO to stop charging royalties on varieties older than 20 years old, such as Dutch Robijn. It remains to be seen what deliberations by seed potato stakeholders will resolve on percentages and modalities for charging royalties.

Government-led joint venture on aeroponic seed production: A new potato production unit licensed by KEPHIS, was set up in Nyandarua County as a joint venture between the National Youth Service (NYS) and the Prisons Service in February 2019. The seed multiplication uses aeroponic technology and has a capacity of 6,000 plants that can yield up to 429,000 tubers which can be further multiplied to millions of seed. The variety propagated is Shangi due to its high demand. This is contributing to meeting the shortfall is seed but stakeholders call for similar facilities to be set up for seed of highly-demanded processing varieties, whose seed is currently imported.

RECOMMENDATIONS

- **Encourage private sector collaboration with the government in production of Early Generation Seed (EGS).** Public-private partnerships could establish strong operational and institutional foundations that facilitate ease of sharing of technology and boost production capabilities of government facilities. Past pilots funded by USAID and involving KALRO and CIP were successful in crowding in the private sector; resulting in a 10-fold increase in the availability of basic seed over three years. Learnings from this pilot could be leveraged to design PPPs for EGS production, and crowd in the private sector who can invest in quality control systems, breeding programs, and staff training and development.
- **Encourage farmers to grow certified seed, employ good agronomy and be linked to high-value ware potato markets.** Promotion of cultivation of non- Shangi varieties including imported ones would involve initiatives such as supporting ware potato farmers to secure firm contracts with price guarantees from high-end processors of chips and crisps; promotion of royalty-free varieties such as Dutch Robijn; increasing availability of seed of these varieties at the right price and time as required by farmers as well as farmer education on these varieties and agronomic support for ware production. Improved yields and income from ware potato farming will increase their ability to afford quality seed, whether in the form of mini-tubers or cuttings. These steps would gradually move them toward demanding and purchasing certified seed potato.

Reform policy to allow private seed certification and support private testing laboratories

- **Kenya should consider reforming its seed inspection and certification policies to streamline and fast-track these processes**: provided there are no threats to the country's biosecurity. KEPHIS should also consider reviewing its regulations to benchmark with Zambia and South Africa in having satellite testing of seed, and private seed certification to increase speed and capacity.
- **Use university and other government land as Pest Free Areas for seed potato multiplication.** Universities and the ADC Farm have access to large tracts of unused, arable land that has previously not been used for seed or ware potato production. This land is free from PCN and Bacterial Wilt. Like in Egypt and Japan, these can be developed into profitable and sustainable seed potato production zones, and through a PPP avail the private sector of optimal seed potato production zones, while universities would deepen their industry collaboration, raise

funds to maintain these farms and trigger training and postgraduate employment opportunities for their agriculture students.

- **Conduct further research on compelling business models for incentivizing the private sector to use tissue culture instead of tuber basic seed.** Private sector companies interviewed do not see a clear business case for investing in seed potato multiplication from tissue culture, as it takes a minimum of four years to make money compared bulking seed from mainly imported tubers as a starting material. Stokman Rozen is an exception, and is making inroads in bulking seed potato through cuttings (see Box 1[6]). Crowding in the private sector will significantly increase the availability of quality, disease-free seed, thereby reducing the current shortage. South Africa has a robust seed potato industry, and it imports tissue culture starter material.
- **Explore the potential of clustered seed multiplication**. Seed companies and county governments should promote clustered seed multiplication in isolated areas with large tracts of land in counties such as Samburu and Nakuru where land is available and suitable for potato production. Through clustered seed multiplication, there will be aggregation of demand for farm inputs, mechanization with the attendant advantages of economies of scale. Through this model, there would be site-specific extension on agronomy, seed inspection and certification. This system will facilitate crop rotation, effective enforcement of contracts by county governments and seed companies and would yield high volumes of quality seed.

Box 1: Seed Potato Cuttings Production by Private Sector Companies: Stokman Rozen Kenya Ltd

Stokman Rozen Kenya Ltd (SRK) is one of the private sector companies involved in commercial production of rooted potato cuttings, following successful trial phases with CIP in Kenya.

"We are pleased with the current pace that this technology has been introduced, trialled and is fast gaining acceptance by seed producers" says Simon Ndirangu of SRK.

SRK has been in the young plants' propagation business for the past 20 years, mainly in the flower industry. Recently, the company has chosen to diversify its enterprise to contribute to food security in Kenya and has embraced potato cuttings. The firm has experienced staff working in one of the best tissue culture laboratories in the country and can multiply any potato variety on behalf of a seed company client. Current varieties being multiplied by SRK include Dutch Robijn, Unica, Shangi, Konjo, Sherekea, Kenya Mpya, Asante and Desiree.

In-vitro mother plants are grown in a restricted access net house that is designed to keep out sucking pests that can introduce viral diseases. Cuttings from the mother plants are harvested, rooted in cocopeat plugs and are generally ready for delivery to clients within four weeks having been grown under a strict hygienic environment. The growing environment and hygiene procedures serve to guarantee the quality of cuttings that meet and exceed all KEPHIS requirements for the production of clean healthy cuttings.

The firm plans to multiply imported varieties and is looking for partnership opportunities with importers of highly-demanded processing varieties though royalties currently restricted this.

Source: CIP website and stakeholder interviews

[6] https://cipotato.org/potato-seed-for-africa/rooted-apical-cuttings-boost-potato-seed-systems-kenya/

A seed potato screen house
Credit: Vivian Atakos (CIP)

3. Seed Potato Importation Sanitary and Phytosanitary Issues

OVERVIEW OF SANITARY AND PHYTOSANITARY ASPECTS IN SEED POTATO IMPORTATION IN KENYA

All seed importers are required by law to have registered with KEPHIS as seed merchants. A Seed Import Permit and Plant Import Permit must be obtained from KEPHIS before any importation is undertaken. Once the Seed Regulation Form (SR3) is filled and submitted with a registration fee, KEPHIS inspectors visit the applicant's premises to verify the details provided in the form. This visit informs the inspectors' decision whether to recommend an 'approval', 'rejection' or 'holding for further investigation' status. A valid Seed Merchant License allows for importation or export of seeds. The Plant Import Permit (PIP) is obtained by completing and submitting Form SR14. The PIP contains information on harmful pests and diseases that are not known to occur in Kenya.

Globally, several international organizations, conventions and treaties deal with the regulation of seed trade. Together they provide an international regulatory framework by overseeing the interests of breeders, producers and consumers. Among these organizations are the Organization for Economic Co-operation and Development (OECD), whose Seed Schemes are globally recognized for the certification of seed in international trade[7]. The International Seed Testing Association (ISTA) developed globally recognized standard procedures for seed sampling and testing[8]. The International Union for the Protection of New Varieties of Plants (UPOV) provides breeders of new plant varieties with intellectual property protection[9], while the International Seed Federation (ISF) provides seed companies with trade and arbitration rules. Complementary to these are international conventions and treaties hosted by the Food and Agriculture Organization of the United Nations (FAO) that provide the international regulatory framework for seed trade,

7 The **OECD Scheme** for the Varietal Certification of Seed **promotes the use of certified agriculture seed** that is of consistently high quality. The certification involves tests to establish seed quality; potential performance of a seed lot with characteristics based on trueness to type. The characteristics include maturation and storability of the seed, minimum germination, limits of moisture content and limits of seed-borne diseases. Other quality aspects evaluated by a laboratory may include seed size and weight, seed vigour, seed viability and varietal quality assessment, which may include the detection of genetically modified organisms.

8 ISTA standards guarantee the identity of the seed lot with a single reference; the traceability of the analysis; the competence of the laboratory that did the analysis; the use of standard procedures, units and reporting languages

9 The rights granted to the breeder of a new plant variety that give the breeder exclusive control over the propagating and harvested material. With these rights, the breeder can choose to become the exclusive marketer of the variety, or to license the variety to others. To qualify for these exclusive rights, a variety must be new, distinct, uniform and stable.

including plant health and phytosanitary measures, access and benefit-sharing for plant germplasm and use of pesticides.

ISTA standards govern Kenya's international seed trade. ISTA standards guide Kenya's seed potato imports; specifying quality criteria based on seed class (pre-basic seed, basic seed, and certified seed). Before seed is imported, it must meet ISTA standards' limits for maximum percent of off-types, a minimum number of inspections, minimum germination per cent, minimum pure-seed by weight, and maximum per cent moisture. For seed to be traded in it has to be accompanied by ISTA certificates: Orange International Seed Lot Certificate (OIC) or a Blue International Seed Sample Certificate (BIC).[10] Regardless, even with an ISTA Certificate, seed consignments undergo further analysis by the importing country's National Plant Protection Organization (NPPO) and standards body as a precautionary measure. The case of Kenya is similar to seven other African countries governed by ISTA through accreditation of its testing laboratories. The other African countries include Egypt, Malawi, South Africa, Uganda, Zambia, and Zimbabwe. (Keyser, 2013).

Additionally, Kenya observes the UNECE Standards S-1 governing the marketing and commercial quality control of seed potato[11] and adheres to International Standards for Phytosanitary Measures (ISPM) 33 on pest free potato micro-propagative material and mini-tubers intended for international trade.

Considering the high susceptibility of potato to pests and diseases, phytosanitary control is vital. Under the terms of the International Plant Protection Convention (IPPC), exporters of plant products are required to obtain a phytosanitary certificate from their NPPO. This contains information on the importing countries' zero-tolerances for various pests and diseases risks; which must be absent from the seed export consignment. In addition to routine border inspections, for example, some importers will ask for pre-shipment samples from the exporting country two to three weeks before the expected arrival date so that various types of analysis can be implemented. (Keyser, 2013).

These internationally-recognized sanitary and phytosanitary standards and procedures are important in regulating global seed trade and maintaining the biosecurity of nations in the highly-interconnected global seed potato value chain.

Comparison of Tolerances Levels by Seed Class

The EU is Kenya's main source of seed potato imports. Its seed potato production, certification and trade standards are aligned with those of ISTA, UPOV, and UNECE. A comparison of the seed importation and export standards and zero-tolerances for pests and diseases of global economic significance follows below (see tables 4 -6).

From tables 4 and 5 above, there are similarities between Kenya and the EU in terms of zero-tolerances for the major pests and diseases, those classified as 'quarantine'. Similarly, from table 6 below, these same pests and diseases have zero-tolerance standards in Egypt, the EU, Kenya, Morocco, and Scotland. These pests and diseases have the potential to cause seed potato losses of 30% - 100%.

A comparison of zero-tolerances for seed potato pests and diseases of global economic significance is below (see Table 6).

Analysis of Sanitary and PhytoSanitary Variables Across Comparator Countries

The study analyzed the sanitary and phyto-sanitary landscape of 12 countries including Kenya (see table 7). Japan, though having different agro-ecological zones from Kenya's, was selected for benchmarking of best

[10] An ISTA accredited laboratory can only issue both certificates. OICs are issued when both sampling from the seed lot and testing of the sample are carried out under the responsibility of an ISTA accredited lab; BICs are issued when sampling from the seed lot is not under the responsibility of an ISTA accredited laboratory and the accredited facility is only responsible for testing the sample as submitted. See: www.seedtest.org

[11] United Nations Economic Commission for Europe (UNECE). (2014). UNECE Standards S-1 concerning the marketing and commercial quality control of seed potatoes. New York and Geneva: United Nations. Retrieved from https://www.unece.org/fileadmin/DAM/trade/agr/promotion/Brochures/SeedPotatoes/HighResolution_English.pdf

Table 4: Individual Tolerances for Pests and Diseases in European Seed Potato Classes

Individual Tolerance during Production in Europe			
Diseases, pests, damage and defects	**PB TC Class**	**PB Class**	**Basic**
Group 1 – Quarantine Pests and Diseases			
Wart Disease (*Synchytrium endobioticum (Schilb.)*)	NIL	NIL	NIL
Potato Tuber Eelworm (*Ditylenchus destructor Thorne*)	NIL	NIL	NIL
Potato Cyst Nematode (*Globodera* species infesting potatoes)	NIL	NIL	NIL
Ring Rot (*Clavibacter michiganensis (Smith)*) Davis et al. ssp. NIL sepedonicus (Spieck & Kotth) Davis et al.)	NIL	NIL	NIL
Brown Rot (*Ralstonia solanacearum (Smith) Yabuuchi* et al.)	NIL	NIL	NIL
Potato Tuber Moth (*Phthorimaea operculella (Zell)*)	NIL	NIL	NIL
Potato Spindle Tuber Viroid	NIL	NIL	NIL
Colorado Beetle (*Leptinotarsa decemlineata (Say)*)	NIL	NIL	NIL
Group 2 – Rots			
Dickeya spp	NIL	NIL	NIL
Blight (*Phytophthora infestans (Mont.) de Bary*)	NIL	0.2%	0.5%
Blackleg (*Pectobacterium spp.*)	NIL	NIL	0.5%
Gangrene (*Phoma species*)/Dry Rot (*Fusarium species*)/Wet Rot	NIL	0.2%	0.5%
Frost damaged tubers	NIL	0.2%	0.5%
Group 3 – Surface Diseases			
Skin Spot (*Polyscytalum pustulans* (Owen & Wakefield) M.B. Ellis	NIL	0.2%	2.0%
Black Scurf (*Rhizoctonia solani Kuhn*)	NIL	1.0%	3.0%
Powdery Scab (*Spongospora subterranea* (Wallr) Lagerh)	NIL	1.0%	3.0%
Common Scab (*Streptomyces species*)	NIL	5.0%	5.0%
Group 4 – Defects and Damages			
Blemishes such as damaged or misshapen tubers	3%	3%	3%
Group 5 – Soils			
Dirt or other extraneous matter	1%	1%	1%

PB = Pre-basic **PB TC** = Pre-basic Tissue Culture
Source: European Communities (Seed Potatoes) Regulations 2011

production practices[12]. The EU countries were selected since they are major seed potato exporters while the African countries were considered since they have similar origins of seed potato imports and agro-ecologies. The aspects considered include:

- Certification based on OECD standards
- Sanitary and phytosanitary standards based on ISTA standards[13]
- Variety release procedures based on UPOV standards[14]

[12] Japan produces its foundation seed in strictly isolated fields surrounded by protected 'shelterbelts' – free from any pathogens, animal or non-staff traffic. The National Center for Seeds and Seedlings (NCSS) follows strict procedures that include: containing potato production around the farms; using vehicle washing facilities to disinfect them; observing a 5-year crop rotation to maintain the soil fertility combined with rigorous periodic control of pests and diseases. See https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4374560/

[13] For seed to be traded in the study countries that observe the ISTA standards, they have to be accompanied by ISTA certificates.

[14] UPOV membership provides for Plant breeders' rights (PBR), also known as plant variety rights (PVR).

Table 5: Tolerance Levels of Seed-borne Potato Diseases in Kenyan Seed Potato Classes

Potato diseases	Breeder/ Minitubers	Minitubers	Basic seed	C1	C1
Blackleg *(Pectobacterium spp. and Dickeya spp.)*	NIL	NIL	NIL	NIL	NIL
Severe virus disease e.g. PLRV, Y group of viruses, severe mosaic	NIL	0.1%	0.4%	0.8%	1%
Mild mosaic virus visible in the field (e.g. PVX, PVS)	NIL	0.03%	0.03%	0.2%	0.5%
Fusarium wilt	NIL	NIL	NIL	0.2%	0.5%
Verticillium wilt	NIL	NIL	NIL	0.05%	0.1%
Bacterial wilt or Brown Rot *(Ralstonia solanacearum)*	NIL	NIL	NIL	NIL	NIL
Wart disease *(Synchtrium endobioticum)*	NIL	NIL	NIL	NIL	NIL
Nematodes *(Meloidogyne spp., Ditylenchus spp.)*	NIL	NIL	0.2%	0.3%	0.4%
Golden nematode *(Globodera rostochiensis and Globodera pallida)*	NIL	NIL	NIL	NIL	NIL
Ring rot *(Clavibacter michiganensis subsp. Sepedonicus)*	NIL	NIL	NIL	NIL	NIL
Potato spindle tuber viroid	NIL	NIL	NIL	NIL	NIL
Phytoplasma diseases e.g. Potato stolbur and potato purple top	NIL	NIL	NIL	NIL	NIL

Source: Seed Potato Production and Certification Guidelines. KEPHIS

Table 6: Global Comparison of Zero-Tolerances in Seed for Major Potato Pests and Diseases

Disease	Kenya	UNECE	Egypt	Scotland*	Morocco
Bacterial wilt or Brown rot (*Ralstonia solanacearum)*	✓	✓	✓	✓	✓
Wart disease *(Synchytrium endobioticum)*	✓	✓	✓	✓	✓
Golden nematode *(Globoder rostochiensis)*	✓	✓	✓	✓	✓
Ring Rot *(Clavibacter michiganesis)*	✓	✓	✓	✓	✓
Potato Spindle Tuber Viroid	✓	✓	✓	✓	✓
Mycoplasma	✓	✓	✓	✓	✓
Root rot nematode *(Ditylenchus destructor)*		✓		✓	✓
Root knot nematode *(Meloidogyne spp*		✓		✓	✓
Potato Tuber Moth *(Phthorimaea operculella)*		✓		✓	✓
Potato Cyst Nematode - PCN *(Globodera spp (in production land)*	✓	✓	✓	✓	✓
Colorado Beetle *(Leptinotarsa decemlineata)*					
Potato Tuber Eelworm *(Meloidogyne chitwoodi, M. fallax)*				✓	✓

** Scotland observes a zero-tolerance during seed potato production and is restrictive on imports. Scotland is the only seed exporting country in Europe where potato brown rot has never been found: a great selling point for its seed industry.*

This analysis reveals that the majority of the countries have 2-3 seed certification classes. Therefore the push by Kenyan seed companies for the C3 seed class is validated by the practices of other countries. On SPS measures, all the countries analyzed have zero-tolerance policies particularly for bacterial wilt, golden nematode, wart disease, potato spindle tuber viroid, and ring rot which are difficult to mitigate. Lower classes of seed, i.e. pre-basic and basic seed are required to have greater purity and quality for multiplication; with more stringent zero-tolerances. The higher the seed class the greater the degeneration in quality, and the vulnerability to pests and disease. The analysis revealed that consequently, the threshold for certain pathogens

Table 7: Analysis of Sanitary and Phyto-Sanitary Variables Across Comparator Countries

Country	Kenya	Zambia	Zimba-bwe	Egypt	South Africa	Morocco	Ethiopia	Uganda	Tanzania	Scotland	Japan	Nether-lands
Seed Certification												
Seed Generations	5	8		4	8	7	6			7		10
Certified Classes	3	4		1	2	2				-		3
Have QDS System	X	✓	✓	X	Standard grade	X	✓	✓	✓	X	X	X
Private Certification	✓	✓	✓	X	✓		X	X	X			
Observes OECD Scheme	✓	✓	✓	✓	✓	✓	X	✓	✓	X	✓	✓
Members of OECD	X	X	X	X	X	X	X	X	X	X	✓	✓
SPS Measures												
Zero-tolerance Policies Imports	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ISTA Accredited Labs	✓	✓	✓	✓	✓	X	X	✓	✓	✓	✓	✓
Observe ISTA Standards	✓	✓	✓	✓	✓	✓		✓	✓	✓	✓	✓
Have a Pest Free Zones/Sites	X			✓						✓		✓
NPT, DUS & Variety Release												
NPT/VCU (Seasons)	2 – 3	2	2	2	Not needed for variety release	2	2 - 3	1	1			
No of Sites VCU	5	6	5		-				3			
DUS (Seasons)	2	2	1-2 years	2 years	1			2	2	2		
No of Sites DUS	2	6						4				
Variety Release duration (from application to release)			1-2 years		After one season of DUS	2 years	2 years	2.3 years	3 years			
Uses Other Country's data	✓		✓	✓					✓			
Members of UPOV	✓	X	X	✓	✓	✓	X	X	✓	X	✓	✓
Plant Variety Protection (PVP)	✓	Draft	✓	✓	✓	✓	✓	Draft			✓	✓

Source: IFC Analysis, 2019

is lowered for certified seed classes. From this analysis and stakeholder views, it is proposed that zero-tolerance policies and standards be reviewed, and be applied only to pre-basic and basic seed classes since invariably the certified classes of seed may have some infection which may be undetectable during seed testing and inspection shows that zero-tolerances.

The zero-tolerances are more stringent for lower seed classes (i.e. pre-basic seed), and Kenya like Egypt could obtain a scientific basis for revising its zero-tolerance on the traded seed classes which are basic seed. On average, for variety release, the VCU and DUS trials are run for two seasons in two agro-ecological zones. In Kenya, the minimum period is two years under rain-fed conditions but KEPHIS allows for intensive NPTs under irrigation. The period is extended due to the time taken by the variety release committee to meet and deliberate on the variety release process and outcome for new varieties. The proposed strategies for improving and benchmarking Kenya's seed potato import SPS practices are in the sections that follow.

EU seed exporters and scientists jointly reviewed the behaviour of seed potato pathogens absent in the EU but later found in seed once seed was planted in Egyptian and Moroccan fields. Through extensive field research conducted jointly with Egyptian and Moroccan certification agencies, these joint teams were able to determine that the higher temperatures and tropical conditions promoted the greater prevalence of some of the zero-tolerance pathogens and that zerotolerance standards were to be revised in light of this. Egypt, like Kenya, imports its seed potato from the EU including Scotland yet has managed to control major pathogens like bacterial wilt/brown rot due to technical, evidence-based, and scientific sanitary and phytosanitary approaches (see boxes 2 and 3 for details on Egypt's best practices).

OPPORTUNITIES AND RECOMMENDATIONS FOR ENHANCING IN SEED POTATO IMPORTATION SPS IN KENYA

- **KEPHIS should establish a robust mechanism and system for assessing the biosecurity threats of seed imports.** The Open Quarantine System together with laboratory and manual inspection are expensive to administer and time-consuming in establishing results from potential biosecurity threats. The Open Quarantine System involves KEPHIS setting up a seed potato trial in an isolated area on suspecting an imported seed potato shipment of having a latent infection of pathogen not present in Kenya. KEPHIS will sample the seed potato lots and based on laboratory test results, the sample will be planted in the Open Quarantine site for one year.

Box 2: Egypt's Robust Potato Industry: A Snapshot

Egypt is Africa's largest potato producer and ranks 14th in the world in terms of ware potato production. It also produces about 700,000 – 800,000 tons of local seed potatoes from imports which go into crop production the following season. Egypt is largely dependent on seed potato imports for its domestic potato production. Imports in 2018 (January-October) reached roughly 120,000 metric tons. Imports originate mainly from the European Union (EU): the Netherlands (40,500 tons or 33.6 per cent), United Kingdom/Scotland (40,400 tons or 33.5 per cent), and France (18,900 tons or 16 per cent).

Egypt's yearly imports of seed potatoes average $85 million (from 2015-17). Egypt's phytosanitary regulations require laboratory testing against Potato Brown Rot (*Ralstonia sloanacearum*) and ring rot diseases' causal agents in all imports and exports of potato. Egyptian exports of ware potatoes to the Russian Federation, EU, Lebanon, and Jordan are permissible only if produced in Pest Free Areas (PFAs).

Egypt's enviable position as a key trading partner in EU's food and agriculture is attributable to the systematic and scientific approach to mitigation of SPS risk factors.

Box 3: Egypt's Best Practices in Managing Seed Potato Pest and Diseases

Pest Free Areas (PFAs): For nearly 30 years, Egypt struggled with low potato production and trade due to infestations with Potato Brown Rot. Through EU financial and technical support, Egypt set up the Pest Free Areas (PFAs) for seed potato multiplication and ware potato production. Seed potato is also multiplied in these PFAs to ensure there is no cross-contamination between seed and ware potato. The government also set up the Potato Brown Rot Project (PBRP), through which the PFAs are managed under the aegis of the Ministry of Agriculture and Land Reclamation. The Potato Brown Rot Project (PBRP) is exclusively responsible for PFA establishment, inspection, monitoring, and maintenance, as well as for laboratory testing against brown rot disease's causal agents. The PFA s were set up in accordance with the International Standard for Phytosanitary Measure (ISPM)- 4 "Requirements for the establishment of pest free areas." A minimum rotation of 3 years is applied and seed potato crops can only be planted in recognized PFAs (free from Potato Brown Rot infestation).

Double Seed Inspection: Egypt's seed inspectors are stationed in the seed potato exporting countries to inspect and test the seed at all key stages. In Egypt, the country has designated seed potato inspectors who inspect seed potato at designated ports of entry for seed potato imports. These two ports are separate from each other to reduce any potential cross-contamination. This system has increased the capacity of Egypt's seed potato inspectors in seed potato SPS matters while improving trade relations with major EU seed exporters by reducing the instances of seed consignment rejections and associated costs. Non-compliant seed lots are not issued with an import permit by the Egyptian authorities in the country of origin.

EU Partnerships on Potato SPS: Egypt has collaborated with French, Dutch and Scottish seed potato SPS experts, trade ministries and seed potato trade agencies in setting up long-term partnerships that have: built capacity in joint pest risk assessments, provided technical and scientific data on performance of foreign pests and diseases under Egyptian conditions and lastly fostered greater trade ties. Through these collaborations, Egyptian SPS officials have visited the seed potato countries of origin to understand the growing conditions, observe and inspect the crops in the field, postharvest and just before shipment. These efforts have informed initiatives in mitigation of both known and unknown pests and diseases including Common Scab, Powdery Scab, Silver Scurf, Potato Mop Top Virus (PMTV) and Tobacco Rattle Virus (TRV).

The KEPHIS team will observe the performance of the seed potato and the emergence of the suspected pest or disease. If the pathogen does not emerge or manifest, then the trial data is entered into the NPTs, and the seed potato importer can continue with the multiplication and related processes. However, if the sample turns out to be infested, then the whole shipment is destroyed. The seed importer pays for the OQS assessments and disposal of material if it is rejected. A new mechanism of effectively capturing all potential threats at ports of entry is needed since the costs and length associated with the OQS are high and are borne by the seed importer.

To prevent seed with potential quality issues landing at the port of entry, KEPHIS should explore mechanisms of conducting pest risk analysis (PRA) in the country of origin. Current practice involves collaborating under ISTA and OECD provisions for mutual SPS quality assurance. Egypt has found a way around this by using seed quality inspection officials based in its consular offices in the exporting country to ascertain that the seed export documentation and seed quality standards are at par with Egyptian and international seed quality standards. Additionally, Egypt has deployed seed potato inspectors in key seed potato

exporting countries, and these inspectors conduct potato inspections throughout the value chain: from field production through to harvesting, processing, and packing to pre-export. Egyptian seed inspectors issue an import permit (into Egypt) based on the inspection outcome and conformity to standards for major pests and disease, including zero-tolerances for the major ones (see Box 3 and Annex 5 on proposed seed importation protocol for Kenya).

- **KEPHIS is encouraged to consider adopting a risk-based seed importation policy and to revise the quarantine pest and diseases list based outcomes of the ongoing pest risk analysis.** Kenya is conducting its first ever pest risk analysis (PRA) to establish the baseline situation regarding bacterial wilt and PCN. KEPHIS and CABI are jointly conducting the PRA with development partner support. The PRA data and a risk-based approach will guide regulations, initiatives and investments in managing existing risks and controlling new ones. It will also guide the revision of the quarantine pest and diseases list. There is also an opportunity to build a scientific basis for revision of zero-tolerance levels through technical and scientific collaboration with the major seed potato exporting countries in Europe as was done in Egypt (see Box 3). The collaboration would involve sharing of technical data, joint PRAs, and extensive field-based research in Kenya to determine the performance of major pests (known and unknown) in Kenya's agro-ecologies.
- KEPHIS should lower National Performance Trials' costs and timelines for imported seed, currently at $3,563 for two seasons. Recommendations include using data for only one season, and also considering trial data from varieties registered in 2 COMESA or SADC countries. In South Africa, the variety testing and release processes on seed potato include only Distinctiveness, Uniformity, and Stability (DUS) and not Value for Cultivation and Use (VCU) data, provided the variety meets the DUS criteria. This shortens the process and eliminates additional costs. As highlighted earlier, there is an opportunity for private seed certification and inspection by KEPHIS to ease the backlog of seed inspection demands by seed companies. This model works very effectively in South Africa and Zambia, where it is supported by training and certification of seed inspectors; and regular auditing of both private inspectors and laboratories for continued compliance.
- KEPHIS should advocate for the importation of tissue culture material for multiplication. If commercially viable, direct importation of tubers (pre-basic and basic seed) should be phased out gradually as capacity and investments are leveraged to support tissue culture seed potato production. It is easier to meet infection-free standards for in vitro than it is for tubers. The government should provide tax rebates to incentivize seed importers to use tissue culture propagation material to ramp up availability of material and support initiatives in increasing access to blended finance for seed companies using the imported tissue culture starter seed to meet the initial capital outlays.
- East Africa NPPOs can strengthen cross-border SPS capabilities through a regional program on capacity building and awareness creation. There are three main regional entry points of seed potato into the country: Taveta, Malaba and Lunga Lunga. KEPHIS is working on educating the public on the importance of these border control points in safeguarding the country's potato industry through minimizing or eliminating biosecurity threats. KEPHIS has also previously built the capacity of Tanzania's seed inspectors on seed potato testing through targeted SPS training for officials from the Tanzania Office of Seed Certification and Inspection (TOSCI). KEPHIS has a robust training program that can be adapted for training the EAC region's SPS teams to strengthen cross-border SPS capabilities.
- Regional collaboration on the strengthening of the One Stop Border Points (OSBPs). Seed regulatory agencies must clarify the procedures required at One Stop Border Points established to enhance EAC cross-border trade. KEPHIS has officials and testing capabilities at six of these OSBPS. Efforts should be made to improve the SPS capacity of the remaining border posts in Uganda and Tanzania in terms of infrastructure and human resource.

- The Electronic Single Window System (eSWS) has shortened the importation process and reduced associated costs. However, there is a need for a strong human interface with the electronic system to ensure that biosecurity is safeguarded effectively.
- The EAC governments should support the border point and the laboratories with more manpower and equipment for rapid identification of potato diseases. The equipment should ensure accurate identification of the diseases of concern from each of the trading partners. Examples of such methods include Loop mediated isothermal amplification (LAMP), Polymerase Chain Reaction (PCR), and genome sequencing using the new technology.

Potato is the second most important staple after maize in Kenya

Credit: Hugh Rutherford (CIP)

SEED COMPANIES SHOULD SIMPLIFY INFORMATION, EDUCATION AND COMMUNICATIONS MATERIALS THAT INCLUDE PRODUCTION CALENDARS FOR EACH VARIETY TO ENABLE FARMERS TO PLANT DURING THE CORRECT SEASON TO GUARANTEE HIGH YIELDS.

Using certified seed potato can dramatically increase ware potato yields

Credit: V. Atakos (CIP-SSA)

4. Seed Potato Marketing and Distribution

OVERVIEW OF SEED POTATO MARKETING AND DISTRIBUTION CHALLENGES IN KENYA

Stakeholders shared their views[15] on several marketing and distribution challenges which include: the bulky and perishable nature of potato seed; mainly rainfed seed production that cannot meet demand; lack of demand data in terms of seasonality, varieties and quantities of seed demanded; inadequate extension messaging and marketing collaterals to accompany seed sold to farmers; lack of controlled environment storage in seed production zones to maintain quality and even out seed supplies.

OPPORTUNITIES AND RECOMMENDATIONS FOR STREAMLINING SEED POTATO MARKETING AND DISTRIBUTION

The main recommendations made by stakeholders were around: extension, decentralized seed companies, demand estimation and stimulation, warehouse investments, vertical integration of ware processing companies and leveraging agritech solutions for demand aggregation and distribution.

Extension

- Seed companies should invest in extension to stimulate demand for seed of high-value processing varieties through setting up of demo farms.
- Seed companies should effectively communicate with farmers about breaking seed dormancy to ensure that seed germinates. They should prioritize selling seed whose dormancy has been broken. This will encourage farmers to try new varieties, especially those with high yields and excellent processing qualities but have long dormancy periods.
- Seed companies should highlight the agronomic requirements of the intensive high-yielding imported varieties; these include intensive spray regimes, high fertilizer and irrigation requirements, and postharvest storage to avoid sprouting.
- Seed companies should simplify information, education and communications materials that include production calendars for each variety to enable farmers to plant during the correct season to guarantee high yields. Simple fliers, brochures and radio messages work best.

[15] IFC organized a stakeholders' workshop to review the findings of the analysis and to discuss emerging opportunities, required policy reform actions and needed investments to spur the potato industry's end to end growth (seed to ware). This workshop was followed by a farmer field day at NYS Tumaini Farm in Nyandarua to showcase the high-capacity aeroponics seed potato facility. The review of distribution and marketing was beyond the scope of this study; nonetheless the stakeholder engagements yielded valuable insights on key recommendations.

- Processors should collaborate with seed companies in setting up demos close to ware farmers, and during the demo field days, processors should exhibit ware potatoes in high demand for processing; sharing characteristics and explaining market value.

Vertical Integration

- Processors should strengthen the 'fork to farm' linkages by vertically integrating their operations into ware and in some cases seed production, and working closely with both ware and seed farmers to ensure adequate quantities and quality of the in-demand processing varieties.

Decentralized Seed Companies

- Satellite seed production sites and operations should be set closer to the main ware potato production zones to reduce the distance travelled to seed companies, to lower overall seed costs by lowering costs associated with transportation of bulky seed potato thereby stimulating purchases. Combined with decentralized seed testing, inspection and certification, this could be a gamechanger in promoting the use of quality certified seed by ware farmers.

Warehouse Investments

- Warehouses are vital for ensuring that seed quality is maintained in the postharvest period at seed companies, and in the pre-planting period by ware farmers. Some cases of quality deterioration in seed purchased by ware farmers are reported to be attributable to poor storage in unsuitable stores. Counties, seed companies and other players can engage in PPPs to design and implement viable storage solutions that are fit-for-purpose for smallholders, farmer groups and semi-commercial seed multipliers to mitigate this challenge.

Demand Estimation and Stimulation

- There is a need for a mechanism for accurately estimating and communicating the active seed potato demand in the country. Currently there a disconnect between what varieties farmers want and what seed companies are multiplying and marketing. For instance, data on the volumes of seed demanded for the top 5 processing varieties is not readily available. This would be useful in guiding seed companies and processor investments and open up new markets for varieties that are currently being imported for high-value frozen chips processing.
- Seed demand efforts will include the approaches highlighted above under extension in addition to processors offering attractive contracts to ware farmers who will in turn, invest in quality seed of the right varieties thereby stimulating demand.

Disruptive Agritech Platforms for Aggregation and Logistics

- Emerging opportunities such as digital agritech platforms for aggregation and logistics can enhance farmers' access to quality, affordable seed at their farmgate.
- Firms such as iProcure are working in rural Africa on streamlining input supply chains with promising digital agritech innovations (please see Conclusion section for details).

Youth are finding profitability opportunit... in seed potato productio...
Credit: Hugh Rutherford (CIP)

Conclusion

Kenya's potato industry presents a multi-million-dollar opportunity for seed potato value chain actors. Reaching 40% of ware potato farmers (up from the current 4%) with certified seed potato would require strategic policy reform actions to streamline identified seed multiplication and importation bottlenecks matched with investments in irrigation, seed cold storage, mechanization and improvements to seed inspection capabilities.

The study identifies five priority areas as outlined earlier and summarized below.

Support production and use of apical cuttings as seed potato

Production of seed from apical cuttings by seed potato companies offer a two-fold increase in yield over use of mini-tubers. Not only are they cheaper per unit but also reduce susceptibility to and proliferation of seed potato pests and diseases. This offers a promising route for accelerated seed potato production. Increasing investments in apical cutting production over the medium to long term will increase the availability of quality seed potato and contribute to reducing the annual seed potato gap in demand of more than 300,000 tons. KEPHIS has developed certification guidelines for apical cuttings and is working with the government and private sector to increase availability of apical cuttings. Apical cuttings offer farmers the opportunity to effectively and safely produce quality seed that they can use for one or two seasons, starting with clean, certified seed potato.

Reform policy to allow private seed certification and support private testing laboratories

Recently KEPHIS has enhanced speed of seed certification through training, authorizing and gazetting 28 private seed inspectors from private seed companies and county governments. KEPHIS through its Centre of Phytosanitary Excellence (COPE) should partner with agricultural universities, county governments in potato growing areas and private seed companies to identify agriculture graduates who can be trained en mass to reduce the seed inspector shortages. COPE already has a curriculum that covers seed potato production, phytosanitary issues and seed certification. Coupled with this, KEPHIS is encouraged to enhance the authorization of private seed certification services and facilities. These initiatives would require an innovative PPP and policy advocacy to leverage investments, and to create the needed regulatory change to allow for KEPHIS-accredited private seed certification. These are short- to medium-term initiatives.

Reform policy to allow for collaboration in production of Early Generation Seed (EGS) by government and private seed companies

To ensure continuity of the gains made in creating a vibrant seed potato industry in Kenya, the government could collaborate with the private sector in production of Early Generation Seed (EGS). This would not only increase availability of foundation and breeder seed potato but would also ensure that seed companies produce varieties with farmer-demanded attributes. Currently, production of early generation seed is the sole mandate of the national research agency (Kenya Agricultural Research Organization (KALRO) that cannot produce the quantities of breeder and foundation seed required by the industry. Policy advocacy for reforming the current seed laws to recognize early generation seed production from the private sector is needed. Similarly, investments in KALRO should support the maintenance of public seed potato varieties where these have significant market demand, and support a PPP on EGS production for in-demand high-value varieties. Lessons from EGS pilots should be leveraged for scaling up an EGS PPP. The private sector should lead new variety development where it has a competitive edge.

Recognize Quality Declared Seed (QDS) system in Kenyan seed laws

A Quality Declared Seed (QDS) system also known as a Quality Declared Planting Material (QDPM) system is a quality assurance scheme for seed production that is less demanding in comparison to the standard quality control systems. QDS is formally recognized by FAO and some national seed certification agencies in Africa; with QDS quality standards being defined by the latter. QDS systems allow for less rigorous and low-cost inspection regimes while producing quality, clean disease-free planting material from registered varieties. QDS systems act as a bridge for formal seed producers: facilitating access to quality seed for smallholder farmers while serving as a basis for creation of future certified seed demand. Generally, the production and marketing of QDS is limited to a specific jurisdiction, managed by local governments and may be traded on a limited scale. Ethiopia, Uganda, Tanzania and Zambia formally recognize the production, inspection and cultivation of QDS for potato. Investments and policy advocacy are required in the immediate to medium term to support the line ministry, KEPHIS, county governments and smallholder farmers in the move towards QDS systems. Through a collaborative PPP, KEPHIS would be supported to develop guidelines and inspection capabilities, while county governments would be supported in enforcing the QDS jurisdiction. Private seed companies would sell the certified starting seed potato material to county governments or farmer producer organizations in these schemes.

Explore and scale disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs

Currently, the newly emerging ware potato production zones are geographically dispersed; with on average more than 400 kilometres to be covered to the nearest seed potato company, which is often located in another county. This situation has further impacted the lack of seed potato for ware farmers at the critical moments during planting seasons as seed is not available when and where required. The bulky nature of seed potato propagation materials coupled with the long distances to seed producing farms, increase the cost of transportation and the overall cost of certified seed potato.

There are opportunities for exploring and scaling disruptive agritech aggregation and logistics platforms to reach farmers with seed at the farmgate at lower costs.

Digital agritech solutions exist that can be leveraged to simultaneously increase availability and reduce transportation costs by facilitating the generation of geo-located bulk orders, and combining smart logistics to transport seed to farmers within specific localities. Currently, seed companies post their seed inventory on a members' only dashboard such as ViaziSoko (managed by National Potato Council of Kenya) and farmers who need seed can communicate directly via phone with the seed company. The seed company prepares the order and once ready the farmer is required to collect it immediately from the seed company's farm due to the

highly perishable and bulky nature of seed tubers and cuttings. This represents complex logistics that can be mediated by agritech innovations.

The World Bank's Agriculture Global Practice is working with agritech innovators who can be involved in generating or scaling this solution. One such innovator is iProcure – a firm that is using data analytics to aggregate demand and last mile distribution networks to enhance agricultural supply chains in rural Kenya. The Potato Council is also working with Viazi King - a logistics company to develop the digital platform that would leverage the power of data analytics and fintech for payments. These innovations could be explored for lessons on adaptation and scaling to reach the 800,000 ware potato farmers in Kenya.

DATA-DRIVEN DISTRIBUTION

Through real-time business intelligence, we provide an alternative distribution channel that ensures your product gets all the way to the end consumer.

STAY IN THE KNOW

Know who is buying, when and for how much; iProcure provides complete supply chain visibility.

WAREHOUSING

Our storage facilities are strategically located to ensure extensive reach to the rural consumer. Our predictive algorithms ensure that essential commodities are never in short supply.

LAST MILE

Getting it there. Rapid order fulfillment to wherever your customer is.

iProcure is an inputs supply firm operating in Africa to bridge last-mile access challenges by leveraging the power of data analytics. Such technologies have the potential for improving distribution channels for seed potato in Kenya.

Increasing potato productivity is core to the Food and Nutrition Security Pillar of the Big 4 Agenda.

Credit: FIPS-Africa

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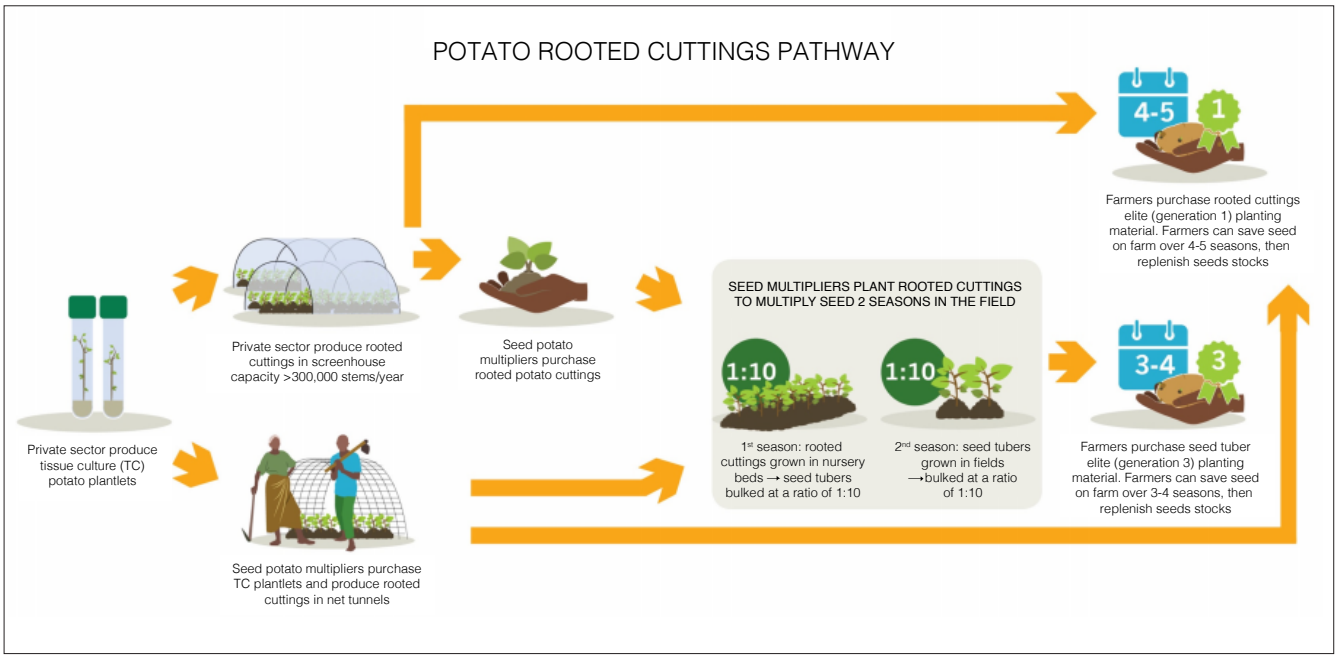
ANNEXES

Annex 1: Seed Potato Producing Companies in Kenya

Seed Company	Location	Variety
Aberdare Technology Ltd	Muranga	Shangi, Dutch Robijn, Unica, Asante, Kenya Karibu
ADC: Molo	Nakuru	Shangi, Sherekea, Dutch Robijn, Kenya Karibu, Kenya Mpya, Bvumbwe, Asante, Desiree, Kenya Mavuno, Rolin Tana, Kenya Sifa, Tigoni
Agrico East Africa	Nakuru	Markies, Destiny, Manitou, Rudolph, Arizona, Arnova, Carolus, Faluka, Zafira, Kuroda
Baraka Agricultural College	Nakuru-Molo	Shangi
Clabhan Investment Limited	Nakuru	Shangi, Dutch Robijn
Gene Biotech Seeds Ltd	Kajiado	Shangi
GTIL	Nairobi	Dutch Robijn, Shangi and Konjo
IPM & Kevian Kenya seeds (Kirinyaga seeds)	Kiambu	Shangi, Unica and Dutch Robijn
KALRO Tigoni	Kiambu	Shangi, Tigoni, Unica, Kenya Karibu, Sherekea, Kenya Mavuno, Wanjiku, Nyota, Lenana, Annet, Chulu, Dutch Robijn and Kenya Mpya
Kenya Highland Seeds (Royal seed)/Danespo	Nairobi	Royal, Sarpo Mira
Kisima Farm	Meru	Tigoni, Asante, Sherekea, Kenya Mpya, Shangi,Dutch Robijn, Unica, Farida, Derby, Sagitta, Taurus, Challenger, Evora, Panamera, Rodeo, Sifra, Voyager, Zarina
Savannah Fresh Hort. Farmers' Cooperative Society Ltd	Meru	Asante, Sherekea, Unica, Dutch Robijn and Konjo
Seeds2B Africa Ltd	Meru	Shangi
Sigen Hortipruse Ltd	Elgeyo Marakwet	Shangi, Dutch Robijn
Singus Enterprises	Nakuru:Molo	Shangi, Dutch Robijn, Unica
Spring Valley (Moiben)	Uasin Gishu	Shangi, Dutch Robijn
Starlight Cooperative society	Nakuru: Molo	Shangi and Sherekea
Stockman Rozen Ltd	Naivasha	Apical stem cuttings and mini-tubers of Shangi, Unica, Konjo, Dutch Robijn, Wanjiku, Asante
Suera Farm/C. Meijer B.V	Nyandarua	Musica, Lady Amarilla, Acoustic, Lady Terra, Rock
Wanfa Technologies	Nyandarua	Shangi, Unica

Source: CAP 326 i.e. Seed and Plant Varieties Act of 2012

Annex 2: Cuttings Production Cycle



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Annex 3: Methods of Seed Multiplication

i. Hydroponic Production

In hydroponic production, plant roots are freely suspended in nutrient solution from which they derive essential nutrients and trace elements. A plantlet can produce 9-13 minitubers (CIP, 2018). The method requires optimization of production conditions specifically, a balance between the nutrient ratios within the nutrient solution, electrical conductivity value, and pH as for potato production (Virtanen & Tuomisto, 2017).

ii. Aeroponics Production

Aeroponics production exploits vertical space to optimize the development of roots, tubers, and foliage through provision nutrient solutions. The system can produce impressive 37-47 mini-tubers per plantlet. This notwithstanding, it is more costly and risky as it needs continuous flow of electricity. It also requires more skills than the conventional technique and hydroponics, which are more resilient with less upfront and running costs. (CIP, 2011). This system reduces the impact of serious soil-borne disease constraints such as bacterial wilt. KALRO-Tigoni has an aeroponics facility for large scale productions.

iii. Positive Seed Selection

The positive seed selection principle designed by International Potato Centre, CIP, involves selection and marking of the best plants in a ware field as mother plants for seed generation. This methodology was developed to bridge the deficit of sufficient certified seed (Gildemacher, et al., 2011). The simple, low-cost technology enhances the quality of seed potato used by smallholder farmers. This technique works not only against viruses and bacterial wilt but also against other seed-borne diseases.

Positive selection has been proven to be a promising complementary practice for smallholder farmers in Kenya. The fact that it has the potential to increase smallholder yields without monetary investment and it fits well into the prevailing seed sourcing strategy of smallholders, which is largely based on self- and neighbour supply makes it a valuable complementary practice. (Gildemacher, et al., 2011)

iv. Seed Plot Technology

This approach utilizes the principle of maximizing tuber production per unit area and disease-free land area through high-density planting in seed plots; 112,500 plants/ha. The tubers used in this method have to be of exceptional quality, preferably certified. The advantage of the seed-plot technique is that it provides a platform free infested and infected tubers through intensive management practices against bacterial wilt and other tuber-borne diseases. According to Kinyua et al. (2011), this technology can achieve 2.5 to 3 times higher land productivity for bacterial wilt-free seed potato, translating into a 50 per cent less land required to meet on-farm seed tuber demand.

Annex 4: Scotland's Tolerance Levels for Basic Seed Potatoes for Export

Tuber Inspection Tolerances - Non-EU

The following minimum tolerances are used for Basic seed potatoes produced in Scotland for export outside the EU (and to the Canary Island) unless the importing country's requirements are stricter.

Disease, Pest, Damage or Defect	Individual Tolerance[1]	Individual Tolerance for surface area cover	Group Tolerance[1]	Collective Tolerance groups II, III & IV[1]
Quarantine organisms (Group I)			NIL	
Wart Disease *(Synchytrium endobioticum)*	NIL			
Potato Tuber Eelworm *(Meloidogyne chitwoodi, m fallax)*	NIL			
Potato Cyst Nematode *(Globodera rostochiensis, G, Pallida)*	NIL			
Ring Rot *(Clavibacter michiganensis ssp. sepadonicus)*	NIL			
Brown Rot *(Ralstonia solanacearum)*	NIL			
Potato Tuber Moth *(Phthorimaea operculella)*	NIL			
Potato Spindle Tuber Viroid	NIL			
Colorado Beetle *(Leptinotarsa decemlineata)*	NIL			
Rots (GROUP II)			0.2%	
Rots including blight *(Phytrophtora infestans)*	0.2%			
Blackleg/ bacterial soft rot *(Pectobacterium ssp.)*	0.2%			
Blackleg *(Dickeya ssp.)*	0.0%			
Gangrene *(Phoma foveata)*, Dry rot *(Fusarium)*, Wet rot *(Botrytis cinerea)*	0.2%			
Surface diseases (Group III)			1.5%	
Skin spot *(Polyscytalum pustulans)*	0.5%	12.5%		
Black scurf *(Rhizoctonia solani)*	1.5%	12.5%		
Common scab *(Spongospora scabies)*	1.5%	12.5%		
Powdery scab *(Spongospora suterranea)*	1.5%	12.5%		
Other defects and damages (Group IV)				
External blemished or atypically shaped tubers[2]	1.0%			
Superficial necrosis by PVY	0.1%			
External necrosis by other viruses	2.0%			
Total (Groups II, III & IV)				4.7%
Soil			0.5%	
Dirt or other extraneous matter	0.5%			

Tolerances are by weight: 2 includes tubers wrinkled or dehydrated due to the silver scurf *(Helminthosporium solani)*

Annex 5: Proposed EU Seed Potato Import Quality Assurance Protocol for Kenya

Proposed Protocol for Quality Assurance for Kenya's Seed Potato Imports from the European Union

Following a review of global seed importation standards and seed potato import protocols of Egypt, Scotland and Wales, the following protocol is proposed to enhance the sanitary and phytosanitary quality of EU seed potato imports to Kenya.

The Ministry of Agriculture, Livestock and Fisheries, the Ministry of Trade and KEPHIS shall consultatively align Kenyan seed potato import requirements with the UNECE, ISTA and IPPC standards and build the capacity of Kenyan seed potato inspectors (dedicated KEPHIS officials) in identification, inspection and testing for seed potato pests and diseases of economic importance in global trade. This shall be through a collaborative arrangement with the EU, as was done for Egypt. Like Egypt, Kenya shall have seed potato inspectors stationed in main seed potato exporting countries to inspect seed during planting, after planting and at harvest to determine adherence to pest and disease tolerances as per the Kenyan, ISTA, UNECE, IPPC and individual EU country SPS standards.

(i) The Kenyan seed potato inspectors shall collect these data: farm name, farm location, farmer registration number, variety name, area planted, lot number, intended/projected date of export to Kenya, and final destination in Kenya, including details of importing entity.

(ii) Data on these seed potato production sites should be fed into a central digitally-accessible database for comparison and full traceability throughout the seed potato value chain.

(iii) Kenyan seed potato inspectors shall inspect the seed potato in the pack houses, testing for any infestation from packing crates, machinery or facility.

(iv) A pre-export inspection shall be conducted a minimum of 72 hours before the intended shipment date and the lot either certified as fit for export or declared unfit for shipment to Kenya, based on the aligned tolerance levels for seed potato pest and diseases, as well as seed potato quality standards (size of tubers, % off types, tuber firmness). The seed potato exporter shall be issued by KEPHIS, an export permit in addition to export permits from the EU, individual country and UNECE as applicable. Digital copies of these permits shall also be entered into the centralized digital database and shared together with the final seed inspection report, with KEPHIS seed potato inspectors based at the seed potato import port of entry In Kenya. Like Egypt, Kenya shall have a dedicated port of entry for all EU seed potato imports, with dedicated seed potato inspectors similarly skilled in rapid, near-real time seed inspection and testing techniques as their counterparts based in the EU.

(v) KEPHIS shall demand that all exporters of seed from Britain, France, Ireland, and the Netherlands give a 48-hour written pre-notification of an incoming seed potato shipment, to alert KEPHIS officials in Kenya.

(vi) The written notification must contain the following information:

- time, date and means of introduction
- point of entry
- final destination
- intended use (for example ware production, trial seed or seed production)
- variety
- quantity (in tons)
- producer's identification number (grower number as it appears on the label)
- certified grade (for example PB, S, SE, E)

(vii) On arrival at the port of entry, no seed potato will be allowed off the shipping vessel before phytosanitary and quality tests have been conducted to determine pest and disease tolerance levels as per the agreed upon, harmonized standards. The seed potato inspectors will sample 200 tubers for each 25-ton container of seed. The presence of any pest or disease with a zero-tolerance will result in the seed shipment being returned to the country of origin. For pests and diseases on allowable quarantine lists (see pages 24-26), the rapid, near-real time techniques[1] will be used to determine the levels of latent infestation and the biosecurity threats posed by the seed potato shipment. If the threat is serious then the seed shipment will either be returned to the country of origin or ordered destroyed at the expense of the seed exporter and sanctions imposed on the exporter such as missing two potato seasons. No infested seed should be allowed on Kenyan soil as it could destroy both the seed and ware potato industries through latent infection which can last up to 20 years depending on the pathogen.

Notes: The costs incurred by the seed exporter/importer in conducting tests under quarantine conditions and condemning a seed lot after one season will be avoided.

Advantages of the Proposed Protocol

- The use of rapid, high-precision inspection and testing techniques will reduce the time taken to inspect seed import shipments from 14 days to just a few hours.
- The quick turnaround of the seed inspection and testing in the country of origin will be useful in decision-making regarding whether or not to proceed with the shipment.
- The double inspection, in the country of origin and in the destination (Kenya) will give added assurance of the rigour and credibility of the KEPHIS pest risk assessment protocol and process.

[1] A best practice to include is the rapid, near-real time assessment of risk and infection using Loop-mediated isothermal amplification (LAMP), genome sequencing and similar modern seed inspection and testing technologies. Field deployable LAMP Assay has proved to be efficient and effective as it is sensitive, rapid (results in 20 minutes to 1 hour), and accurate and does not require sending samples to the lab for analysis. It is suitable for on-site, field-based diagnosis be it farmers' fields or port of entry. It is cost-effective and can be used by non-laboratory staff: medium-to-large scale seed potato producers can easily integrate LAMP Assay into self-assessment of their seed quality.

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