Designing self-sustaining early generation seed supply systems: *the must-dos*

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Abstract

Shortages in the supply of quality early generation seed (EGS) of new and improved varieties, particularly of dryland cereals and legumes is a major challenge because of the business models. This triggers the following questions: what EGS business models would sustainably avail quality parent seed?

To investigate this, we documented 16 EGS interventions. We found that pre-securing seed market ahead of production played important role in the successful seed business. Taking different forms (e.g., pre-orders, demand forecasting, pre-aggregation of demand, joint planning, contractual agreement), it brings confidence to EGS producers to continuously invest in the business and make it profitable.

For sustainable EGS production and supply in sub-Saharan Africa, we advocate for market assurance in advance. Two guiding principles are also suggested and four recommendations formulated.

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1. Background and objective

Enhancing seed producers' access to parent seed, also called early generation seed (EGS), remains a challenge for National Agricultural Research and Extension Systems (NARES), international agricultural research and development organizations like the CGIAR, and even to donor communities (USAID, BMGF, etc.).

High quality seed of improved varieties is critical to enhance crop productivity and production. Therefore, sustaining access to EGS (pre-basic or breeder seed, and basic or foundation seed) is a critical step toward effective supply of quality certified seed and quality declared seed (QDS) of modern and high-yielding crop varieties. For most developing countries in sub-Saharan Africa (SSA), the EGS problem remains unresolved, though many studies have been carried out and recommendations made over time.

Yet, EGS is central to sustainable seed system to produce and market modern varieties, quality seed supply, increasing productivity and achieving sustainable development goals 1 and 2. The critical and relevant question that still remains unanswered is what EGS business models would sustainably avail quality parent seed?

To answer this important and persistent question, we thought that it will be useful to question the existing literature by analyzing the past and current EGS experiences. Identifying the best practices and uncovering the critical factors shaping access to EGS for non-hybrid legume and cereal crops would inform policy interventions that support efficient production and supply of EGS in SSA. We recognize that access and availability of quality seed for various players requires an integrated approach that generates financial benefits to value chain actors, including farmers.

The uptake of these improved varieties is significantly constrained by the unavailability of quality seed that is attributed to several factors and among them is the weak functioning EGS systems. This policy brief critically analyzes sixteen previous and present EGS interventions and provides pathways to sustainably address the inherent challenges, most importantly, for non-hybrid dryland cereals and legume crops.

2. EGS side of quality seed production and supply

Limited and unsustainable supply of EGS reduces the capability of the seed supply system to avail quality certified seed to farmers. The rapid adoption of improved varieties remains dependent on EGS component to support production of enough certified seed and QDS. In many developing countries, public entities, and most importantly research institutes still play a major role in production and supply of EGS.

Most of the time, the public organizations have limited capacity to handle the national needs of EGS. Usually, NARES still lack physical infrastructures, human and financial resources to sustainably handle EGS. For less commercial and non-hybrid crops/varieties, the extent of supply is very limited. In most developing countries, the seed policy hardly provides mechanisms for the production and supply of EGS at scale.

It is often observed that very limited amounts of EGS is available, especially for the newly released varieties. Very few countries have established functional public private partnerships to effectively avail EGS. In the private sector, except for a few (e.g., SeedCo), most African seed enterprises lack physical facilities and capacities to handle the whole variety development chain, including breeding components. This is the reason why most of these rely on public-released varieties and public institutions for EGS that is used to produce certified seed.

3. Analysis of past and current EGS seed business models

We performed a thorough analysis of past and current experiences to document lessons and inform future interventions for a sustainable EGS production and supply system. A total of 16 experiences of EGS business models were analyzed and 13 presented in Table 1.

The typology used to categorize the business models led to public institutions-led models, private institution models and public-private partnership models (Table 1).

Most business models involve a portfolio of crops including non-hybrid cereals and legumes. Self-production or contract farming arrangement are used by EGS actors to meet their production targets. Contract farming usually arises when a company has a large market demand that it cannot meet on its farm alone. The main practices keeping companies in business include seed demand forecasting, pre-order of seed, joint planning with partners, non-exclusive licensing, private seed companies buffer stocks, and revolving fund. Seed demand vagaries, poor/lack of infrastructure to produce EGS, mismatch between pre-basic and basic seed demand, high costs of supervising and managing outgrowers seed producers, and poor-quality seed jeopardize EGS production and supply systems.

Table 1: Analysis of EGS business model experiences

Business Model	EGS production strategy	Innovative practices	Challenges
Public sector models			
INRAN Seed Unit, Niger (Groundnut, cowpea, millet sorghum)	Seed production on station; contract seed companies.	Contract with private seed companies.	Getting seed companies to embrace new varieties; demand forecast challenges.
Ethiopian Institute of Agricultural Research (EIAR), Ethiopia (Chickpea, common bean)	EIAR breeding programs produce and supply Ethiopian Seed Enterprise (ESE) with breeder seed; ESE produces breeder and basic seed it farms located in different agro-ecological zones.	Demand projections done by regional Bureaus of Agriculture (pre-ordered seed); ESE receives a budget allocation for seed production; annual demand projections are provided by the regional bureaus of agriculture.	Seed production infrastructure.
KALRO Seed Unit, Kenya (Beans, wheat, soybean, sorghum, maize, finger millet)	KALRO gives initial seed grant; breeders produce pre-basic seed; outgrowers produce foundation seed; KALRO licenses private seed companies.	Joint planning by KALRO centers; revolving fund (80% retained for seed production, 20% to KALRO); issuing non-exclusive license agreements to private seed companies.	Management of outgrowers is costly, inadequate seed production infrastructure.
ICAR Rice model, India (Rice)	Research institutes (SAUs and ICAR) produces and supply breeder seed of notified crop varieties to both public and private seed companies.	Indents compiled and forwarded to ICAR 18 months in advance; seed companies submit orders to ICAR before season outset; buffer stocks to mitigate risk of unmet demand; set seed management information system.	Infrastructural deficiencies; poor quality of breeder seed.
Private sector-led models			
Legacy Crop Improvement Centre, Ghana (Maize, cowpea)	Seed production on drip irrigation farm.	Invested in seed infrastructure (irrigation and cold storage); access to regional ECOWAS market.	Demand forecast challenges.
SOPROSA-Sarl, Mali (Sorghum, pearl millet, groundnut)	IER supplies pre-basic seed; Seed production throughout the year on own irrigated farm.	Invested in seed production infrastructure (irrigation system for production).	Popularizing new varieties; demand forecast challenges; weak technical capacity of human resources; costly management of outgrowers
Premier Seed Ltd, Nigeria (Maize, cowpea, sorghum)	Research farm with irrigation facilities; outgrowers scheme.	Invested in seed production infrastructure (irrigation system for production).	Demand forecast challenges.
Public-private partnership models			
Seed Revolving Fund, Malawi (Groundnut)	Contract farmer seed producer clubs; foundation seed sold to seed companies; seed sales re-invested to cover operation costs.	Contract farming; revolving fund to finance seed production operations.	Weak capacity of the national Seed Services Unit; costly management of out growers; demand forecast challenges.
IITA GOSeed, Nigeria (Banana, yam, cassava, maize rice, soybean, cowpea)	Outgrowers produce foundation seed; farm with irrigation.	E-commerce platform; seed tracker system.	Demand forecasting challenges.
Seed for seed Ltd-NARO Holdings, Uganda (Common bean, groundnut, rice)	Produce at a nucleus farm Contract research Zonal institutes; contract local seed business members.	Active solicitation of orders from seed companies; cost recovery financing approach; decentralize production to agro-ecological zones.	Costly to manage outgrowers; side selling by growers; poor demand forecast; tax issue; protracted procurement processes.
Highland beans Egerton University, Kenya (Common bean)	License seed companies to produce foundation seed.	Seed companies set own production targets; non-exclusive license agreements to seed companies; royalties paid to breeding program.	Demand forecast challenges.
QualiBasic Seed Ltd, Kenya (Maize, common bean)	Outgrowers produce the seed.	Outgrowers with irrigated farms; invested in seed production and infrastructure; buffer volume of seed; soil fertility management.	Seed market vagaries; demand forecast challenges; poor quality breeder seed; breeder seed not matching demand.
Malt barley PPP-Ethiopia (Malt barley)	Pre-basic seed produced by agricultural research institutes; basic seed produced by ESE who may also contract EIAR research farms.	Seed supply pre-determined based on brewing industry grain need; financial support by Heineken to EIAR's and ESE; contract seed producer cooperatives for certified seed.	-No challenge reported

Source. Opie et al. (2022a)

4. Country efforts to resolve EGS equation

Most countries have to some extent implemented mechanisms to sustain EGS availability and supply though little achievements can be observed (Table 2). The country efforts were to create a conducive environment, e.g., enactment of seed acts including bills favoring the private sector investments, plant breeders' rights, plant variety protection, regional harmonization for seed trade/movement across countries, capacity building (human and infrastructure) and accreditation to the international bodies of seed testing, i.e., International Seed Testing Association (ISTA) and Organization for Economic Co-operation and Development (OECD).

Most countries have reached out to the private sector thereby reducing the public sector roles in seed activities and enhancing their roles in EGS. Countries like Rwanda, Kenya and Uganda are good examples to highlight. Public and private partnerships were established for hybrid and OPV cereal crops, the root and tuber crops, cassava and potatoes. Tanzania took necessary measures and got ISTA accreditation for seed testing.

Table 2: Country specific mechanisms to sustain EGS availability and supply

Country	Actions taken towards enhancing EGS availability and supply
Uganda	National Seed Policy and strategy was enacted and approved in October 2018; a national foundation seed enterprise established; Public research institute entered PPP with a brewing company and development partners to enhance commercialization of agricultural technologies in line with their industrial needs; PPP also involves the production and supply of EGS for legume crops like common bean and groundnuts.
Kenya	Functional PPP involving public research organization, seed companies, individual seed entrepreneurs, traders, and processors on various crops; licensing of private seed multipliers, e.g., seed potato, with royalties paid to research institutes for public-bred varieties; seed inspection and regulatory services were revised in 2017 giving the private sector role to support public service on the provision of seed inspection services.
Tanzania	Accreditation of the National Laboratory of the Tanzania Official Seed Certification Institute (TOSCI) by the International Seed Testing Association (ISTA); the PPP set for casava, groundnut, sorghum EGS supply for small scale farmers to have timely access to quality, disease-resistant and higher yielding varieties in desired quantities at affordable price; cassava seed certification and inspection protocol.
Malawi	The capacity of Seed Service Unit (SSU) built; significant improvement in number of seed inspectors trained and deployed to farmer organizations, seed companies, and in SSU; domestication of SADC seed harmonization program; seed revolving fund on legume crops.
Rwanda	Alignment of the national seed laws with COMESA and EAC procedures; removed subsidies on imported seed to reduce seed imports and promote uptake and use of locally produced improved seed; locally produced seed subsidized by 79% against 40% for imported seed. Online application system tailored to increase access to improved seed by smallholder farmers facilitating seed purchase from accredited suppliers by agro-dealers; increased number of functional private seed companies.
Ghana	Seed Regulation Certification and Standards was harmonized with the ECOWAS regulations in 2018; Plant Breeders Bill, Plant Variety Protection Act passed into law in 2020; Seed imports and import licensing procedures have been liberalized. Increased number of seed inspectors; recognition of the role of the private sector in seed systems development; multinational private companies received approval to release high yielding varieties e.g., maize; private sector companies got approval to produce foundation seed if specified requirements met; National Seed Value Chain Business Networking Forum estimated to 200 seed value chain actors.
Nigeria	The Plant Variety Protection enacted; increased private sector participation in production and commercialization of maize, rice, and soybean breeder seed; increased seed quality control and seed sector governance; seed quality control through electronic seed certification system with scratch card authentication.

Source. Opie et al. (2022b)

5. Key learning from past experiences of EGS business models

Financing mechanisms and options play key roles in EGS supply. Like any enterprise, seed production involves infrastructural and financial resource investments to facilitate the acquisition of relevant equipment and facilities for running seed business. Financial mechanisms in place to support EGS business models involve initial financial grants provided by donor organizations directly to private sector-led companies or NARES through different projects.

The production of EGS in most of the public research institutions relied on this funding mechanism through which they continuously run production of breeder and basic seed. The second mechanism is the revolving fund, a financing mechanism that operates on a cost-recovery principle. An initial seed grant is provided to the seed producing unit through which to finance seed production operations.

A substantial amount (about 80%) of the financial proceeds from the produced seed is injected back into actual seed production activities and other operational expenses including warehouse, staff remuneration, certification fees and other administration fees; the remaining 20% remitted to host umbrella organization. International and public research institutions are actively using this method of financing, e.g., ICRISAT in Malawi, NARO in Uganda, and KALRO in Kenya.

The third funding mechanism is direct financing by the private sector for variety development and seed production. Jointly with other relevant value chain actors, the private sector works closely to deliver an intended product essential for its processing. This is the case of Heineken who financially supported EIAR for malt barley seed production in Ethiopia. The guaranteed grain off-take by the brewing company, Heineken, along the financial support to the public research institution, EIAR, made the way to EGS production and further supply of certified seed of malt barley.

Beyond financial mechanisms, other strategies have been developed to ease EGS access. We refer to seven of them as follows: - (i) Decentralized seed production is critical to ease EGS access constraints. Long distances between certified seed and EGS producers negatively affect access and increases supply cost thereby making seed more expensive to farmers. In Uganda for example, NARO and Integrated Seed Sector Development (ISSD) Uganda addressed this challenge by engaging Zonal Agricultural Research and Development Institutes (ZARDI) to produce foundation seed to bring EGS closer to certified and community seed producers.

KALRO in Kenya, and EIAR in Ethiopia are using this approach too by establishing EGS producing units at specific agro-ecological zones. (ii) Non-exclusive rights licensing agreement to private seed companies motivated to produce and supply foundation seed for legume crops. This arrangement comes with payment of some royalties to breeding institute for maintenance breeding. An example is bean varieties released by Egerton University which were licensed to some private companies.

The seed companies obtained non-exclusive rights to produce foundation seed of improved varieties with 5% royalties payment to Egerton University. (iii) Regional seed markets integration is an important mechanism for easing seed flow across countries within the region or economic blocks. Access to regional seed markets represents a major incentive for the private sector to invest in seed business of non-hybrid legume and dryland cereal crops. The wider market opportunities enhance business scale to private seed companies. In West Africa, LCIC markets seed in several countries thanks to ECOWAS regional seed regulation that allows for region-wide marketing of seed of varieties released in at least two countries.

QBS is also surfing on this opportunity in East Africa. (iv) Seed demand creation information forecasting. The promotion of new varieties to stimulate demand goes together with awareness creation activities to stimulate seed demand. Some business models address this through facilitating dissemination and access to information to popularize the improved varieties by leveraging ICTs tools. For example, IITA's GOSeed uses an e-commerce platform to disseminate relevant information and promote their improved varieties.

Stimulating demand is a key driver for EGS off-take. (v) Demand forecasting through seed pre-order and joint planning systems. Forecasting and determination of seed demand is a critical bottleneck in the production of EGS in SSA. Various business models highlighted forecast of seed demand as a major challenge. For ICAR in India, EIAR in Ethiopia, and ISABU in Burundi, EGS seed production is based on a pre-order system in which clients submit well in advance their seed request to facilitate the coordination of EGS production and supply.

In India and similarly Ethiopia, systematic planning of EGS seed production is based on seed orders submitted before the beginning of the season. The seed orders are useful to determine the amount of seed to be produced based on client needs. The system also minimizes risks associated with client behavior to abandon the orders made by requiring a prior deposit towards the ordered seed as a commitment from the clients. (vi) Seed production more than the expected demand. This involves intentional overproduction to create buffer stocks to mitigate seed multipliers' risk of unmet supply of breeder and foundation seed.

A typical example is India's rice system in which the actual production of EGS exceeds the submissions from indenters. QBS in Kenya follows a similar approach. (vii) Seed infrastructure development. Sustained surplus seed production amidst market and climate change risks requires investing in production and storage infrastructure to ensure compliance with quantity and quality of seed desired by the market as demonstrated by private EGS producers as well as the PPP led EGS models.

6. Guiding principles for engineering functional EGS business models in the future

For various stakeholders investing in EGS-related matters for quality seed production and supply to farmers and other users, there is need to have guiding directions for actions. This involves laying key principles to follow to set up a functional EGS supply system. The two key guiding principles are depicted as follows:

- An existing grain market or substantial purpose secures and sustains quantity and quality seed demand
- The private sector investments along the seed and grain value chains are essential to sustain EGS production and supply.

For sustainable production and supply of EGS for most of the non-hybrid dryland cereals and legumes, the entire seed and grain value chains should be considered. Only mechanisms driving the entire commodity value chain and involving the private sector can ensure and sustain availability of EGS.

7. Recommendations/policy options: the *must-dos*

Operationalizing the aforementioned two principles in future EGS interventions involves following these four recommendations:

- Each variety released should respond to a defined and targeted market segment or niche market or defined purpose, be it local, regional or global. The seed market/purpose should respond to quantifiable grain market outlets or purpose. Knowing the grain volume will facilitate backward planning for certified seed, basic and pre-basic seeds. This will also drive (seed) business contracts among partners along commodity value chains
- Each new variety released should come with a minimum amount of buffer nucleus, pre-basic and basic seeds with clear multiplication path whereby the private sector and other key players are given a fair share in the multiplication scheme based on country context. Guaranteeing EGS should start with product developer with seed regulation making provision for volume needed to accelerate multiplication at scale without waiting for years to bulk
- The seed supply systems should involve a pre-booking system. Securing the seed quantity in advance calls for actual seed producer commitment and allows proper planning
- Developing (digital) tools, that are user-friendly to estimate and forecast seed demand will play a major role in the event of vague market.

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