Case Study 5: Seed Production for Vegetative Propagated Crops

Component: Quality seed production

Subtitle: Strengthening seed production systems for vegetatively propagated crops: Lessons from CGIAR studies

Executive Summary:
Asexual plant propagation methods are an easier and faster method of propagation. However, there are currently no dedicated and effective commercial seed systems for vegetatively propagated crops (VPC) in Africa. Africa produces several VPC including cassava, potato, sweet potato, banana, yam, and various vegetable crops. Existing seed systems policies and regulations favor true seed propagated cereals and grain legumes. Studies conducted by Root, Tuber and Banana (RTB) and Program on Policies, Institutions, and Markets (PIM), two CGIAR Research Programs (CRP) show that effective VPC seed systems have to be farmer-based, while policies have to balance a permissive regulatory regime with decentralized production systems, grassroots capacity development, market surveillance, and systems that integrate internal (producer-level) quality assurance with external (regulatory) quality assurance. Developing effective VPC seed systems will require CESSA to address and invest in it.

Context:
Plant propagation is the multiplication of plants from their parent plants. There are two methods of propagation i.e., sexual and asexual propagation (Chauhan et al., 2020). In sexual reproduction crops, seeds can be either directly seeded in the field or transplanted after growing seedlings in nursery beds. Sexual or seed propagation is common in cereal and other seed propagated crops. In asexual or vegetative propagation, plants are multiplied by plant parts that regenerate themselves into new plants.
The methods of asexual propagation followed in VPC are cuttings, bulbs, tubers, crown division, and grafting. Each method of propagation has its advantages and disadvantages. Vegetative propagation is easy, cost-effective, cheaper, and quicker than asexual propagation. Asexual propagation is an easier and faster method of propagation. It bypasses the juvenile characteristics of certain species. The resulting new plants are genetically identical to their parents. Asexual propagation can be done through various approaches such as micropropagation, tissue culture, and aeroponics to produce early and disease-free planting material.
Africa produces several VPC including cassava, potato, sweet potato, banana, yam, and various vegetable crops. The growing awareness of the importance of RTB crops for food security, nutrition, and the income of rural households has led to an increase in the number of projects that introduce new RTB varieties and seed multiplication practices, especially in Africa (e.g., McEwan et al., 2015).
These crops are normally vegetatively reproduced through roots, tubers, or stems with sexual propagation applied only for breeding. This way of propagation makes their 'seed' systems different from real 'true seed' systems.
Farmers cultivating these crops face constrained access to quality planting material. These crops have different biology compared to cereals but also face economic challenges in propagation. Cereal crops, which are seed propagated dominant narratives on seed system reforms. Although technological solutions exist, there are other limiting factors relating to policies, institutions, and markets that shape VPC seed systems, e.g., quality assurance mechanisms, certification regulations, sanitary and

phytosanitary standards, and plant variety protection. One pathway to increasing VPC yields and returns is through the use of quality planting materials by farmers (Almekinders et al., 2019).
There has been interests among national MoA, CGIAR, and universities to study the dynamics of VPC seed systems to develop effective seed systems for VPC in Africa. The CIP-led CGIAR research program on Roots, Tubers, and Bananas (RTB), and the IFPRI-led CGIAR research program on Policies, institutions, and markets (PIM) challenge programs have done significant work in this area.

Challenges and Objectives:
Seed systems for roots, tuber, and banana crops receive relatively little attention from development-oriented research and commercial seed sector actors, despite their importance for food security, nutrition, and rural livelihoods (Almekinders et al., 2019). Though many African farmers and consumers depend on VPC for food and livelihood, their yield and economic returns are below expectations (Spielman et al., 2021).
Most RTB seed systems in developing countries are in 'stage 1', or 'nascent' (in contrast to the 'mature', stage (Douglas 1980, Spielman & Smale, 2017). Their characteristics include a small ineffective formal and public R&D, a rudimentary seed value chain, and the preponderance of farmer-saved planting material (Lynam, 2011; BMGF and USAID, 2015).
The uniqueness of vegetative propagation includes: 1) they can be multiplied 'true to type, i.e., their genotype is fixed, 2) vegetative propagation makes them vulnerable to the build-up of viruses and other pathogens, 3) their bulkiness, low multiplication rate, and perishability have implications for their storability and transportation. The resulting seed systems are quite distinct and characterized by being farmer and trader-dominated, only partially commoditized, dependent on public sector R&D efforts, and less formally regulated.

Because of these three differences, there is less attractiveness for the private sector to engage in RTB seed systems. The result in the country after country is a small or virtually absent formal VPC seed system managed by the public sector. There are exceptions:

1. Extensive research has been conducted on potatoes in industrial countries, accompanied by public policies and regulations designed to advance formal commercial seed systems for the crop. This extensive body of knowledge globally can be drawn on in Africa.
2. The presence of export banana production and/or commercial banana tissue culture laboratories provides a targeted knowledge base and regulations primarily in support of the export sector, although with potential leverage to domestic production.
3. Countries with a growing cassava processing industry represent a similar case.

The formal seed systems for RTB crops are relatively undeveloped and small, even for potatoes (Alkimender, 2021). Adoption of improved varieties of all crops in Sub-Saharan Africa (SSA) is low and shows that access and diffusion of the improved varieties are a general concern (Walker and Alwing 2015). Successful adoption of improved RTB varieties suggests that farmer-to-farmer diffusion operates to generate broad-scale uptake.
Motivations for farmers to seek planting material off-farm include:

1. Farmers' interest in off-farm seed sources to acquire new varieties.
2. Storage seasons and conditions may not allow farmers to save planting material until the next harvest.
3. Farmers simply may not have (enough) planting material from last year's harvest.

4. The quality of seed from normal sources has declined too much to give a proper yield or new yield-threatening diseases have spread.

Vegetative multiplication minimizes problems of the genetic quality of RTB planting material, except when planting material characteristics do not provide evidence of a variety mixture. However, sanitary degeneration of seed due to vegetative multiplication is an extremely frequent issue: the daughter suckers, tubers, and roots growing from a virus or bacteria-contaminated mother plant will usually be contaminated as well. The physiological quality can also be an important concern in RTB crops when planting material needs to be stored for long periods from one harvest to the next. When storage conditions are unfavorable (warm, humid, no cooling facilities) and storage seasons are long, farmers may not be able to keep planting material from harvest to the next planting. The long-distance movements of seed potatoes and sweet potato vines occur in such situations. For potato seed tubers, physiological age is an important aspect of physiological quality for both storage time and conditions (Struik & Wiersema, 1999).

While degeneration of the quality of planting material in RTB crops appears to impact, the effect on yield under farmers' conditions is poorly studied, even in potatoes (Sharma et al., 2016). The general rule of thumb is that with faster degeneration of the farmers' planting material and a larger effect on yield, farmers are more willing to invest in the quality seed.

RTB studied 13 interventions that were supported by public sector researchers and breeders (NARIS), NGOs (e.g., CRS), donors (e.g., USAID), large philanthropic foundations (e.g., BMGF) were justified to:

1. Support seed system development;
2. Mitigate a crop disease emergency (e.g., cassava and banana planting material).
3. Improve food security and nutrition (e.g., orange-flesh sweet potato and bio-fortified varieties).
4. Meet the new opportunities of developing markets; or
5. Promote the adoption of new varieties and technologies (Almekinders et al., 2021).

IFPRI

IFPRI observed the fact that policy and regulatory initiatives designed to strengthen access to quality VPC planting materials have been relatively unsuccessful to date. Their study examined three research questions:

- What types of public policies and regulations govern quality assurance in VPC seed systems?
- How do these policies and regulations influence access, availability, and quality of VPC seed for smallholders?
- What alternative strategies might be employed to increase access, availability, and quality of VPC seed for smallholders?

Interventions:

Root, Tuber and Banana (RTB)

RTB explored the status of practice in seed system development. Focusing on cassava (*Manihot esculenta*), banana (*Musa spp*.), potato (*Solanum spp*.), sweet potato (*Ipomea batata*), and yam (*Dioscorea spp*.), all of which are vegetatively propagated RTB crops that play major roles in the food security and well-being of people in developing countries.

Many of the interventions made use of rapid multiplication techniques — aeroponics for potato, mini-sets for yam, tissue culture, and macro-propagation for banana — to produce clean planting material that farmer groups would further multiply and commercialize (Almekinders et al. 2021). The case studies identified challenges but did not show evidence of many efforts to understand the target seed system

and there were no post-intervention evaluations and reflections. There were no examples where a theory of change was rigorously assessed in the form of an ex-post evaluation. This suggests that monitoring and evaluation in seed systems interventions should emphasize and focus more on learning.
The vegetative nature of the planting material of RTB crops poses huge challenges for a commercial company involved in seed sector development. The ease of multiplying stems, roots, tubers, and suckers suggests that the use of farm-saved seeds dominates. Nevertheless, the research done so far shows that each season a substantial portion of the smallholder farmers makes use of off-farm seed sources.
Group and community-based forms of seed multiplication have been promoted since the 1980s but so far, they have been unable to become a prominent form of decentralized seed supply (Walsh et al., 2015) and the economic sustainability is unclear (Tripp, 2012),
A better understanding through farmer engagement is required for setting up DMs in RTBs (FAO and ICRISAT, 2015). Regular renewal with clean seed and a high variety turn-over in the DMs' portfolio are basic conditions in the case of RTB crops along with a better understanding of farmers' desired varietal traits.
Finally, there is a need to better understand how and what kind of regulations and supporting policies can enhance farmers' access to quality planting material. Each seed system intervention, irrespective of its scale, scope, and duration, touches on existing policy regimes and highlights desirable changes. Quality Declared Seed (QDS) is believed to be a more appropriate regime for conditions in developing countries (FAO, 2010), but field evidence is scarce.

IFPRI
Starting from the observation that policy and regulatory initiatives designed to strengthen access to quality VPC planting materials have been relatively unsuccessful to date, IFPRI drew on a qualitative analysis of policy and practice, to examine reform options related to quality assurance regulations in four crop-country combinations: cassava in Nigeria and Vietnam, and potato in Kenya and Vietnam. The study highlighted theory and evidence on existing models of regulation; alternative models that may better incentivize cost-effective multiplication and distribution; and recommendations for policy, regulation, and investment in VPC seed markets (Spielman et al., 2021).

Results:
From the RTB study, the conclusion was that the use of understanding farmer-based seed systems to reorient ongoing, and design future seed system interventions must be dynamic and adaptive. An improved understanding of farmers' motivations to use (or not use) planting material from formal sector sources is one step towards better-designed interventions for the improvement of RTB crops and seed systems.
To the IFPRI study, each country hosts a legal and regulatory framework governing the seed system; a research system that breeds new crop varieties; a public regulatory body that certifies seed; some combination of public and private seed producers; public agencies, public programs, private companies, and other entities that distribute or market seed to farmers; and widespread practices of farmer seed saving, farmer-to-farmer seed exchanges, and seed exchanges in markets.
The IFPRI study findings indicated that regulations designed around strict and centralized quality control systems tend to limit market size, while more localized production systems are limited by both capacities and reach. These findings suggested the need for alternatives that balance a permissive regulatory regime with decentralized production systems, grassroots capacity development, market surveillance, and systems that integrate internal (producer-level) quality assurance with external (regulatory) quality assurance (Spielman et. al., 2021).

Supporting Visuals or Quotes:

> *To attain availability and access to quality planting material of vegetatively propagated crops there is need for alternatives that balance a permissive regulatory regime with decentralized production systems, grassroots capacity development, market surveillance, and systems that integrate internal (producer-level) quality assurance with external (regulatory) quality assurance (Spielman et al., 2021)*

Future Plans:

Elevating vegetatively propagated crop seed systems to the level of the large formal "true seed" crop seed systems has not been possible in developing countries, especially for root and tuber crops in Africa.

Call to Action (CTA)/Key takeaways:

CESSA could support the current farmer-level seed system for VPC crops in Africa by supporting a set of public policy, investment, and regulatory reforms that:

1. Recognize extant seed systems and end the marginalization or criminalization of informal seed production and trade;
2. Prioritize public investment in early-generation seed production, distribution, and traceability systems;
3. Invest in capacity development for rural entrepreneurs and farmer-based organizations in VPC seed production and marketing;
4. Introduce multiple or alternate seed quality categories such as quality-declared seed (QDS) along with decentralization of quality assurance systems that combine internal systems with external oversight or the threat of such oversight; and
5. Improve assessment and communication of risk associated with biotic and abiotic threats to VPCs that may be mitigated with quality seed and improved genetics (Spielman et al. 2021).

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