Case Study 1: Accelerating Crop Variety Replacement Rates in Africa

AGRA Theme 1: Breeding, variety release, and maintenance

Subtitle: Increased production through replacement of old crop varieties with new and improved varieties.

Executive Summary:
Variety Replacement Rate (VRR) is the replacement rate of crop varieties presently in cultivation with new varieties of the same crop providing greater yields and better products. The average age of varieties in Africa is longer than that in developed countries thus denying farmers the benefits of new genetics to combat stress brought about by climate change. Breeding institutions address VR by developing new germplasm and availing it to the seed industry. Seed companies have a critical role to play in VR and both seed companies and farmers benefit from the timely replacement of obsolete varieties with new varieties with the traits farmers and consumers are demanding. CESSA has a tremendous opportunity to facilitate both public and private sectors to accelerate variety replacement in Africa as the most cost-effective way of increasing productivity and resilience to climate change for African farmers.

Context: What is Crop variety replacement?
Importance of variety replacement
Varietal Replacement Rate (VRR) is an essential factor in realizing genetic gains for enhanced crop productivity. Rapid breeding and varietal replacement are critical to the adaptation of cropping systems in the developing world in relation to climate change (Atlin et al., 2017).

Slow varietal replacement leads to yield stagnation or decline, poor adaptation to climate change and increases the vulnerability of farmers to risks associated with pest and disease outbreaks. Continuing with old and obsolete varieties also leads to customer dissatisfaction, reduced sales, and loss of market share, and eventually affects the brand's perception by the farmers. Planting improved varieties that match farmers' needs and the geography they work in, can increase productivity gains and improve the nutritional status of smallholders. This, in turn, contributes to increased household incomes. Indirectly, the benefits can reach the surrounding community by providing increased employment opportunities, wage increases, and affordable access to food.

Timing of variety replacement
The goal of national seed systems in the developing world should be to ensure that the average age of varieties in farmers' fields is under 10 years, both to ensure that genetic gains are delivered steadily to farmers and to keep pace with the effects of climate change. As critical as the breeding systems; are seed systems that continuously replace varieties, ensuring that farmers are always using varieties selected in the current climate. Breeding organizations, regulatory bodies responsible for the varietal release, national seed systems, and seed companies need to take responsibility for increasing the rate of varietal turnover in farmers' fields. Rapid-cycling seed systems are already in place in commercial temperate cropping systems with highly competitive seed markets, but the situation in the developing world is starkly different, with most farmers still using either landraces or varieties that were released over 20 years ago.

Climate change adaptation in crop production can be delivered by rapid-cycle breeding programs that generate a steadily improving stream of varieties. Climate-adaptive breeding systems must also test potential new varieties in many locations, several seasons, and carefully designed managed environments. These testing conditions will ensure that they are challenged by the range of environmental conditions they will encounter in farmers' fields.

Causes of slow crop variety replacement

The varietal replacement rate is hindered due to cropping pattern and varietal age leading farmers to stay with old varieties due to bottlenecks that include:

1. The lack of access by farmers to reliable information about the advantages of new varieties
2. Seeds of new varieties might not be available for sale where they live.
3. Seeds of new varieties might be too expensive.
4. Failure of new varieties to match old ones in key quality or other characteristics even when they exceed them in yield potential, disease resistance, or stress tolerance.
5. Risk vulnerability: some farmers simply can't afford to take the risk of investing in something that might be good but could also disappoint.
6. Seed companies perceive a certain risk: they might not be interested in taking on an improved variety that trumps the seeds from older but more popular varieties they have on stock.
7. To seed companies, building and marketing a new brand of seeds requires significant investments.

Challenges and Objectives:

Variety replacement in Africa is important for various reasons. First variety productivity is still low and there is a need for farmers to adopt incrementally higher-performing varieties in addition to producing varieties with adaptation to changing climates. However, the average age of varieties in Africa is longer than that in developed countries as the following cases show:

- Challinor et al. (2016) noted that the time to develop and deliver maize varieties in sub-Saharan Africa is currently around 30 years, a period in which substantial climate change has occurred. Farmers in much of the developing world are using varieties selected in a different climate.
- Walker et al. (2015) used weighted average varietal age (WAVA) to indicate the rate of varietal replacement and found the average to be 14 years that ranged from 10.2 for bananas to 20.7 for faba beans.
- Abate et al. (2017) found the area-weighted average age (AWAA) of maize varieties to be 14, 15, and 16 years in Eastern, Western, and Southern African markets, respectively. The estimated AWAA was 13 and 18 years for hybrids and open-pollinated varieties (OPVs), respectively, and 15 years across hybrids and OPVs. Walker (2015) estimated the AWAA of maize varieties in SSA to be 13 years.
- Although new varieties are continuously being introduced into the seed chain varietal scenario at times is dominated by a few varieties having a major percentage share in the total indented breeder seed/basic seed requirement. Almost in all the crops, some of the old varieties still occupy a prominent position by achieving mega variety status (Singh et al., 2019).

Although there is an upsurge of new seed companies in East and Southern Africa (ESA)and the introduction of new varieties with better genetics in the market, some established seed companies continue to sell old (over 15-year-old) varieties (Chivasa et al., 2022, Atlin et al., 2017). Even in systems where seed purchase rates are high, as in hybrid maize in Eastern and Southern Africa, a varietal replacement can be extremely slow when there is little competition among seed companies. Examples include the Kenyan highlands, where hybrids developed in the 1970s and 1980s like Hybrid 614 are still in use. Much of Southern Africa outside of South Africa, 15-year-old hybrids like SC513 are still widely grown despite the existence of much more productive varieties. Experience in Africa shows that high rates of hybrid seed penetration are no guarantee of rapid hybrid turnover.

In most of the crops, some of the old varieties still occupy a prominent position by achieving mega variety status (Singh et al., 2019). Almost all crops listed as cereals (rice, maize wheat, sorghum, and millet) grain legumes (cowpea, pigeon pea, groundnuts, chickpea, lentils, beans), banana and root, tubers (sweet potato, yams, potato, and cassava) had ages ranging from 10.3 (banana) to 24 years (maize in Kenya) (Singh et al., 2019).

Interventions:

Slow varietal turnover is affected by complex cross-sectoral and cross-disciplinary issues that require appropriate policy interventions, including streamlining and regional harmonization of varietal testing and release laws; proper enforcement of seed quality regulations; structured output markets; stable grain prices; and prioritization of modern, climate-resilient and nutritionally enriched crop varieties in the procurement systems during government seed subsidy/relief programs.
To reduce this risk, a strengthened breeding system is needed, with a freer international exchange of elite varieties, short breeding cycles, high selection intensity, wide-scale phenotyping, and accurate selection supported by genomic technology.
Farmers and seed companies alike benefit from the timely replacement of obsolete varieties with new and superior ones: while farmers improve their productivity and resilience to climate-induced stresses and the emergence of new biotic threats, seed companies maintain market share and brand relevance.

Routes towards a replacement of obsolete varieties
Both private and public stakeholders must recognize the need for faster varietal replacement. The typical routes to variety replacement (Chivasa et al., 2022) include:

- External forces including the outbreak of devastating diseases or pests reduce the market attraction of the old variety.
- Replacement of a variety that has declined due to age and as part of product life cycle management policy.
- Replacement of a variety that fails to meet market expectations during the introduction phase.
- Replacement of a market-dominant variety for the benefit of farmers.

Rapid breeding and varietal replacement are critical to the adaptation of cropping systems in the developing world to climate change. Interventions have mainly been by breeding institutions (NARS and CGIAR) and seed companies in the effort to deploy climate adaptive varieties. The steps taken have been 1) the development of superior and climate adaptive crop varieties, 2) studies on variety replacement, and 3) raising awareness on variety replacement to seed companies, regulators, and farmers. A key element in generating a culture of rapid varietal replacement is convincing farmers that it is in their best interest to change varieties as soon as a new one is endorsed and made available by the seed system. The objective of breeding and seed systems serving smallholder farmers should be to ensure that they use varieties developed in the last 10 years. Rapid varietal turnover must be supported by active dissemination of new varieties and active withdrawal of obsolete ones. Faster varietal turnover combined with good agronomic practices in farmers' fields improves yield and adaptation to climate change (Ertiro et al., 2019), leading to improved food security (Lunduka et al., 2018; Cairns and Prasanna, 2018).

Results:

- A recent analysis of the weighted average age of CIMMYT-related improved maize varieties in 8 countries across eastern and southern Africa reveals that the overall average age of improved varieties of maize has decreased from 14.6 years in 2013 to 10.2 years in 2020 (Prasanna et al., 2021). Improved maize varieties offer farmers increased climate resilience, nutritional enhancement, and grain yield; benefiting more than eight million smallholders in Africa.
- Maize variety BH661 bred for mid-altitude Ethiopian markets that combines drought tolerance with high yield, standability, and easy seed production (Ertiro et al., 2019) is rapidly replacing BH660, released in 1993 (Abate et al., 2015; Ertiro et al., 2019).
- Medium-maturing maize hybrid, BH546, replaced BH540 in 2019 BH540 was released in 1995 and dominated the moist mid-latitude maize hybrid seed market for more than two decades.
- Fewer documented examples of variety replacement are found for other staple crops.

Supporting Visuals or Quotes:

Empirical evidence also shows that timely replacement of old products results in better business success as it helps seed companies maintain or improve market share and brand relevance. Therefore, proactive management of product life cycles by seed companies benefits both the farmers and businesses alike, contributing to improved food security and adaptation to the changing climate (Chivasa et al., 2022).

Future Plans:

Replacement of old varieties would present tremendous benefits to farmers and contribute much towards both seed and food security. Variety replacement, however, costs the R&D breeding institution and seed companies, and farmers. It requires proactivity among farmers, enabling policies, a competitive seed sector and national leadership and commitment to invest in agriculture research. Maize and wheat appear to have significant efforts to include variety replacement on the agenda of seed systems in Africa.

Seed companies have a critical role to play in the timely and proactive removal of obsolete varieties from the market and any intervention must address seed company training and support. There is no documented process to help the seed company managers effectively deal with logistics of variety turnover such as inventory management of old varieties and ramping up seed production of new varieties for smooth transitions to new varieties.

CESSA has a responsibility to amplify the importance of variety replacement and to help extend the experiences in the cereals to other crops.

Call to Action (CTA)/Key takeaways:
Proactive management of product life cycles by seed companies benefits both the farmers and businesses alike, contributing to improved food security and adaptation to the changing climate.

CESSA should highlight successful transitions to new varieties, especially for dryland cereals, legumes and vegetatively propagated crops that will be increasingly important for diversifying diets and adapting to climate change.

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