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Seed Systems and Certification

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Introduction

Seed is a basic and fundamental input for agriculture. Accessibility of high quality seed is one of the basic requirements to increase crop productivity, production and use (Pelmer, 2005). The dissemination and use of high quality seeds have great benefits to increase and continue crop production, improve household incomes, minimize risks of insect pests and plant diseases, and enhance the crop production patterns, which would increase agriculture sustainability. So viable seed supply system strategies are important to ensure the availability of good quality seed of varieties to farmers in timely and affordable fashion (FAO, 1999).

Current Seed System in Sub-Saharan Africa

Formal Seed System

Seed system represents involvement and interconnection among different organizations, institutions and individuals associated with development of new varieties and producing, testing, processing, storage, certifying and marketing seed to the farmers. Public and private sectors are highly involved in the production of different classes of seed for domestic/local use and export market. In sub-Saharan Africa, majority of small holder farmers are involved in various kinds of seed systems, which benefit them to produce and obtain the seed they need. There are three broad categories of seed system in sub-Saharan Africa: Formal (commercial) seed system, informal seed system (local seed supply system) and integrated seed system (community based) (Table 1). The detail description of each seed system is outlined below.

The Formal (commercial) Seed System

The formal seed supply system is highly regulated and covers seed production and supply mechanisms. This system involves a chain of activities leading to clearly defined products, i.e., certified seed of verified cultivars (Louwaars, 1994). It involves formal plant breeding, multiplication by seed companies following established procedures including processing, bagging, labelling and marketing. The formal systems also follow the standard of distinctness, uniformity and stability (DUS) of varieties. The system also assures that the cultivar identity and purity are kept throughout various levels of seed multiplication (Breeder/Prebasic to Foundation/Basic to Registered and/or certified seed). The main participants in a formal seed supply system are private and public sectors, and mainly focus on major economically viable crop species with good recurrent seed demands, such as hybrid maize. This kind of seed system is dominant in developed countries. It is a more complex system compared to the informal seed system. The formal seed system produces about 10-20% of the seed demands in Africa (Wekundah, 2012).

Informal Seed System

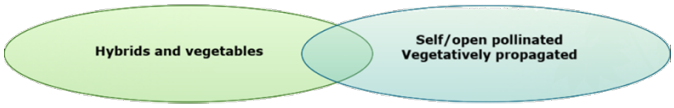
Informal seed supply system is also sometimes called as ‘farmer seed system’ or ‘traditional seed system’. It is a chain of seed multiplication and marketing steps that involve farmers who produce, disseminate or access seed through farmer-to farmer seed exchange based on barter system and through local grain/seed markets mainly based on indigenous knowledge and local diffusion mechanism. In addition, small private companies and farmers cooperatives are involved in seed production in many countries for example, Tanzania, Uganda and Malawi. The informal seed supply system is mostly characterized by its flexibility and operates under non-law regulated conditions. Cultivars may be landraces/local varieties or mixture of different varieties of the same races or may be heterogeneous. Besides, the seed may be of variable quality in terms of purity, physical and physiological quality (Almekinders and Louwaars, 1999). Though the informal seed supply is not formally framed, it covers the majority of seed related activities in most of sub-Saharan Africa and contributes about 80-100% of seed supply to the farmers (Maredia et al. 1999; Wekundah, 2012). It can also enhance wide diffusion of seed over relatively wide areas and promote the small scale seed businesses in the region (Sperling and cooper, 2004). However, little is known about the system, production and marketing chain due to lack of regulation.

The informal seed system is believed to help the farmers due to the following factors:

- Retain seed on farm from previous harvest/farm saved seeds
- Farmer to farmer exchange networks
- The seed do not go under certification process so it is cheaper in price

Seed Sector Development

Table 1 Range of seed sector development. Data from FAO, 2010.

Formal seed system		**Informal seed system**
		
Medium to large	Small scale enterprise	On-farm management

Plant breding capacity	**Limited to public sector**	**Farmer selection**
Variety registration and release process	Not applicable	Inexistent
Early generation seed production capacity	Not applicable	Inexistent
Seed policy and regulatory framework adapted	Inexistent or not always adapted	Inexistent
Seed quality assurance and capacity	Inadequate capacity	Not applicable
Seed production capacity	Limited	Farmer saved seed
Seed conditioning, storage capacity	Limited	Farmer's practice
Entrepreneurial capacity	Limited	Not applicable
Access to credit	Limited	Not applicable
Market access	Limited	Seed exchange or local market
		

Integrated Seed Supply Systems (Semi-formal Seed Supply System)

This is a mix of informal and formal seed supply systems. Small farmers and community-based organizations such as small famers' cooperatives multiply and sell small amount of good affirmed seed of improved cultivars to other farmers within a restricted production area with least possible quality control (Alemkinders and Louwaars, 1999).

Variety Release Regulations

Seed Regulation Systems

Most sub-saharan African countries differ highly in the seed regulation systems. This seed regulation system comprises of seed quality control/certification and cultivar regulation. Cultivar regulation system follows steps to control release of cultivar both by private seed companies and government owned research institution breeding programs. The cultivar registration requires new cultivars to show distinctiveness, uniformity and stability (DUS) and value for cultivation and use (VCU) before being official registered (Setimela et al., 2009). Each cultivar registration is performed by national and private breeding programs. Meanwhile the national cultivar releasing committees have different criteria to register a new variety. Depending on the country's variety release regulations, the DUS and the VCU tests may take one to three years (three seasons) before enough data are available for cultivar registration. The seed law in terms of evaluation and release of varieties are different and inconsistent among sub-Saharan African countries. These different regulations and inconsistent seed laws (and implementation) among countries make it costly and discouraging for private seed companies to release and market their new cultivars.

Most crop breeding programs in sub-Saharan Africa differ in their capacity. Some national and regional crop breeding programs focus on testing lines introduced from other countries, while others have established their own crossing /hybridization programs to develop breeding lines targeting specific and wide crop growing environments. The consultative Group for International Agricultural Research (CGIAR) such as International Maize and Wheat Improvement Center (CIMMYT), International Institute for Tropical Agriculture (IITA), International Rice Research Institute (IRRI), International Crops Research Institute for Semi-Arid Tropics (ICRISAT), International Center for Tropical Agriculture (CIAT) and International Center for Agricultural Research in the Dry Areas (ICARDA) have helped and contributed for crop varieties and other crop technology development (David and Sperlings, 1999).

Common Features of Regulations

In most African countries the following common features of regulations for cultivar release have been established:

- Developed guidelines and standard procedures for testing cultivars proposed for release.
- Independent national varietal releasing committee (NVRC) formed with a mandate to recommend for release or reject based on test results.
- Officially released cultivars that have been recommended by NVRC should be registered and made available to the public. Sufficient information on morphological description, year of release, variety name, and releasing institutions should be clearly indicated.

The International Union For The Protection Of New Varieties of Plants (UPOV)

The International Union for the Protection of New Varieties of Plants (UPOV) is an intergovernmental organization with a goal of providing and promoting plant variety protection (UPVO, 2015). The main objective of UPVO is to strengthen the development of new cultivars that benefit the farmers (UPVO, 2015). The UPOV helps to recognize the rights of plant breeders for the varieties they develop. The UPVO convention provides intellectual property rights to the breeder that enables her/him to have full authority on seed multiplication of her/his cultivar. The breeder's right is implemented if the variety is new, distinct, uniform and stable (UPVO, 2015). Among sub-Saharan African countries, South Africa, Kenya, Morocco, and Tunisia are the only members of UPOV (UPOV 2017). However, Africa has its own regional organization called African regional intellectual property organization (ARIPO) with the main objective of pooling resources of its member countries to solve intellectual property (IP) and related issues through harmonizing IP laws and facilitating IP activities within member countries and distributing of information associated with IP. There are 19 member countries in ARIPO: Botswana, The Gambia, Ghana, Kenya, Lesotho, Malawi, Mozambique, Namibia, Sierra Leone, Liberia, Rwanda, São Tomé and Príncipe, Somalia, Sudan, Swaziland, Tanzania, Uganda, Zambia and Zimbabwe. (**http://www.aripo.org/about-aripo/membership-member-states**).

Plant Breeder's Right

Plant breeder's right: is an intellectual property right granted to a crop breeder in respect to new plant varieties developed by him/her against exploitation without his/her permission. The breeder has exclusive control over his/her new plant materials such as seed, cuttings, tissue culture and harvested materials including fruit and foliage for a number of years. This provides to a plant breeder a recognition and economic reward for his effort and also energizes the plant breeder to continue developing new and better high yield good quality varieties (**http://www.gov.za/services/ plant-production/plant-breeders-rights**). According to South Africa's plant breeders' Rights Act, 1976 (Act 15 of 1976), once the plant materials or cultivars are approved then the plant breeder is given a certificate of plant breeder's right. This plant breeder's right is valid for 25 years in the case of vines and trees, and for 20 years for annual crops, which is started from the date on which a certificate of registration is given.

- Eligibility for protection; the cultivar
- must be new,
- distinct
- uniform
- Stable and have acceptable variety name
- Distinct: it is distinguishable from any other existing cultivars of common knowledge at the time of application.
- The new variety should be uniform: It should be adequately uniform in its unique characteristics.
- The new variety should be stable (DUS): The essential characteristics of the new varieties should remain unchanged after repeated propagation or multiplications.

Who Can Apply

Who can apply for a plant breeder's right: a breeder who bred the cultivars and the employer of the breeder who bred the varieties.

According to the South Africa breeder's right: the following steps must be authorized by the breeder:

- Seed production and reproduction
- Permission for sale
- Exporting and importing

Right of plant breeders: the breeder who developed new varieties has the following rights:

- The right to sell his/her new varieties including the right to delegate other persons to sell or multiply his/her new varieties.
- Full right to multiply his/her new cultivars including the right to authorize other persons to multiply or propagate his/her varieties for sale

Variety Performance Testing

This is a variety trial focusing on the selection of new cultivars with desirable traits that could meet the requirements of farmers or consumers. This test ensures that the new cultivar is similar or better than the existing cultivars in terms of agronomic characters such as grain yield and diseases and insect pest resistance. In majority of sub-Saharan African countries such as in Uganda, Malawi, Ghana, Kenya, Tanzania, Rewanda, Brundi, Nigeria, Cameroon, Angola and Zambia, multi-environments and multi-year variety trials are conducted across different agro-ecological zones to select better performing cultivars (FAO, 1994). The new cultivars have to show better performance in acceptable number of tests in comparison to existing/commercial cultivar(s). The variety performance testing usually includes testing for two to three years in regional or national varietal trials at least in 3 or 4 locations before being recommended for release (Bishaw and Gastel, 2009).

The cultivar which is proposed to be released should be uniform, stable and distinctly better than the existing commercial cultivars in the environments where it is intended to be grown and should have also good agronomic characters and fulfill farmers' requirements. The decision for variety release is made by National Variety Releasing Committee (NVRC). However, in some countries where not enough number of released varieties are available with the unique quality of a particular crop, the NVRC may consider releasing of varieties despite not being better than the existing commercial varieties (Setimela et al., 2009). All sub-Saharan African countries have their own variety release procedure in place even if it is done by an ad hoc committee or by officially assigned authority (Bishaw and Gastel, 2009).

Variety Release

After the variety is officially released and registered, the breeder or institution makes appropriate quantities of the breeder seed and basic seed available for commercial seed multiplication and marketing (Bishaw and Gastel, 2009). In a new development, Drought Tolerant Maize for Africa (DTMA) governed under CIMMYT has proposed a regional harmonization of seed laws in eastern, southern and western African countries, and they will get advantages from the free flow or exchange of maize germplasm across the regions if the regional maize variety release process is implemented. The seed laws allow a maize cultivar released in one country to be considered for automatic release in neighboring countries with similar environments. This helps to release varieties in mega-environments that cover large adaptation zones across country boundaries and also helps to link and create a big maize seed market and fast variety release across the regions (Setimela et al., 2009)

Condition For Release

- Appropriate documents and based on guide, clear morphological description, distinguishing characters, vegetative description and quality test (palatability, taste etc.)
- Sufficient season data from multiple sites [check country registration system guidelines], wide adaptation (at national level), specific adaptation (regional level).
- The new cultivar has to show better performance compared to existing commercial cultivars in environments where it is intended to be grown.
- The cultivars should show distinctiveness, uniformity, Stability (DUS), and value for cultivation and use (VCU).

Seed Quality and Certification

Seed certification is a tool to produce genetically pure and good quality standard seed of improved varieties for farmers. Also, it is appraised for true to type physical purity, germination, seed health and moisture contents, true labeling, backed with appropriate laws and regulation and DUS. The newly released variety must have excellent seed quality attributes which is critical to crop production whereas if the seed is of poor quality, it lowers the potential yield of the variety.

Seed Quality Attributes

- Genetic purity: The seeds have to be genetically pure, this means true-to-type of the specific seed lot. For example breeder seeds must be 100%, foundation seed 99.5%, and certified seed varieties 98 % genetically pure (Brijesh Tiwari, 2014).
- Physical purity or physical qualities: This is characterized by minimum of damaged seed (broken, cracked or shriveled seed), minimal noxious weed seed or other crop seeds and inert matter, minimal diseased seed (discolored or stained seed) in a sample seed lot.
- Physiological attributes/physical qualities: This includes high germination and vigor of the seed.
- Seed health: This refers to free from diseases and insect pests. Example, seedborne diseases could have impact on the health and productivity of the crop which may cause contamination of the seed lot.

Seed Production

Current seed production systems in sub-Saharan African countries include both the formal, which involves both the public institutions and private seed companies, or informal, which includes small scale informal village and community level seed production (Table 3). Hybrid maize seed production is mainly run by both public and private seed companies, whereas legume crops seeds are not extensively produced by public and private seed companies, and they are mostly produced by informal village and community level seed production. Legumes are not widely commercial crops in most Africa countries therefore market demand for good quality and uniform seeds is low (Muigai et al., 2010). In advanced or formal seed production system, five different classes of standard are known, though each country has its own specification based on the affiliate international protocols such as International Seed Testing Association (ISTA) or OECD seed schemes or Union for the Protection of Varieties (UPOV). For example, the seed laboratory of Zimbabwe and Zambia is mandated for seed quality control and is accredited to the international Seed Testing Association (ISTA) (Muigai et al., 2010).

Different Classes of Seed

In sub-Saharan Africa, four major classes of seeds are currently being produced by the public institutions and private companies. Even some of the countries such as South Africa, Kenya and Zimbabwe have accredited seed certification by OECD (Organization for Economic Cooperation and Development (Europe) and AOSCA (Association of official seed Certifying Agency (Table 1).

Seed Classes

I. **Breeder seed:** This is the highest purity of the new cultivar and maintained and multiplied by breeder, and provided to the seed companies for multiplication by breeder's institutions. This class of seed is used to increase foundation seed.
II. **Foundation seed:** This is a class of seed produced from breeder seed. The breeder and research institutions are the ones who help to keep genetic purity and identity. Depending on the seed regulation of the country, foundation seeds could be produced by public or private seed companies.
III. **Registered seed:** This class of seed is produced from foundation seed and is produced by selected farmers and seed companies under the seed regulation agency to keep varietal identity and purity. In most countries, production of registered seed undergoes field and seed (lab) inspection by representative seed inspectors to ensure the fulfillment of the standards.
IV. **Certified seed:** This class of seed is produced from foundation or registered seed, or sometimes from certified seed and is available to farmers for general production. It is grown by selected farmers who have experience and capacity to produce the certified seed. This helps to maintain varietal purity. Production of certified seed is subjected to field and seed (lab) inspection priority to approval by certifying agency.

Comparing Class Systems

Table 2 Seed class system of Organization for Economic Cooperation and Development (OECD) and comparable US seed classes. Data from www.oecd.org.

US Seed Class	Label color	Equivalent OECD Seed Vlasses	OECD Label color
Breeder	-----	Prebasic	White with diagonal violet stripe
Foundation	White	Basic	White
Registered	Purple	Basic	White
Certified	Blue	1st Generation Certified Seed	Blue
Certified produced from certified	Blue	2nd Generation Certified Seed	Red

Table 3 Differences between the formal and informal sector. Data from Minot et al. , 2007

Component of seed system	Formal seed system	Informal seed system
Varietal development	Plant breeders employed by the public institution or private company select for specific traits and produced varietal pure “breeder seed"	Farmers select seed from plants with desirable traits, but the seed is not necessarily varietally pure
Seed production	State or private seed companies multiply seed under strict conditions to avoid mixture of varieties; sometimes contract farmers.	Farmers produce seed along with crops; in some cases the portion of the crop destined for seed is given special management
Processing	Seed is dried using mechanical dryers. Seed may be cleaned by hand, processing machinery used to remove dirt, dried in the sun, and sometimes rocks,	Seed may be cleaned by hand, dried in the sun, and sometimes treated to extend shelf-life.

Component of seed system	Formal seed system	Informal seed system
	and seeds of other plants. May be treated to extend shelf-life.	
Certification	Seed is usually subjected to some formal quality control procedure based on tests of purity and germination of random samples	Seed is generally not tested, certified, or labeled.
Distribution	Seed is bagged and labeled, and distributed by stockists, extension agents, NGOs, and cooperatives	Farmers use seed they save from previous harvest, acquired from other farmers through barter, gift, or sales, or acquired in local grain markets.

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