2 Seed

Tests completed in Uganda in 2015 revealed that seeds sold as hybrid maize in local markets were often not as advertised; less than half of the seeds were authentic hybrid seeds. High yielding seed must be made available to and ultimately adopted by farmers to increase their productivity and meet growing global food demand. However, inauthentic and poor quality hybrid seeds can result in smaller harvests, which ultimately affects farmer's profitability. In Uganda, farmers make the decision to invest in hybrid seed expecting an improvement of their yield. This expectation justifies the higher price paid for these seeds compared to traditional varieties. If the expected yield is not met, farmers are likely to reject hybrid seed.[1] To avoid such a scenario, in August 2016 the government of Uganda launched a campaign to reduce counterfeit seed in the market.

Seed is the most important input in crop production. In most countries, seed supply systems are dual, being characterized as informal (or farmer-managed) and formal. Informal systems are based on small-scale farmers' own efforts to save seeds from their crops, and by farmer-to-farmer gifts, exchanges, and trade. Informal seed systems provide a rich diversity of seed, including varieties that are relevant to farmers and adapted to local weather conditions. They also offer dynamic channels of seed distribution that can reach the most remote farming communities. Finally, they are vital to support biodiversity and resilience against climate shocks.[2] Formal seed systems were built on scientific breeding developed at the beginning of the 20th century by academic research and corporate breeding. Breeding associated with these systems led to an increase of yields, due to a considerable improvement of seed's agricultural productivity, a greater resistance to insect pests and diseases, and tolerance to drought or flood.[3] Formal seed systems generate new varieties that are then released for multiplication and distribution. Informal seed systems are also an important source of seed. Since farmers use both formal and informal channels to source their seeds in most regions, points of integration must be identified to achieve seed security in a balanced seed system that includes formal and informal players. The EBA seed indicators focus on the formal seed system due to the greater availability of comparable data. Formal seed systems are more uniform and are centralized around institutions. The activities performed across the system have been covered by treaties and other international standards. In contrast, informal seed systems are defined by the diversity of practices implemented across countries, or even across regions of the same country. Nevertheless, this year the EBA environmental sustainability topic piloted new indicators that measure innovative practices that support the circulation of seed produced by farmer-managed seed systems. This data, available on the EBA website (http://eba.worldbank.org), measure practices relevant outside of the formal seed system.

Sifting seeds in a field along Red River in northern Vietnam.
Photo: Quy-Toan Do / World Bank.

EBA is committed to developing indicators that support an integrated approach to strengthening seed systems and promote economic growth and poverty reduction. In line with this commitment, the seed indicators will be refined in future years to include practices tested this year in the environmental sustainability indicators, as well as expand the coverage of regulatory aspects relevant to the informal seed sector.

What do the seed indicators measure?

Seed indicators measure laws and regulations applicable to the development, release and quality control of seed, all of which are crucial to increasing the availability and quality of seed reaching the farmer (table 2.1). The seed indicators are organized as follows:

Plant breeding: The development of new varieties is essential to the strength of seed systems. Innovative breeding can increase plant resistance to climate change, lead to higher yields and stimulate an increase in private sector competitiveness. Among other factors, having a legal environment that grants intellectual property rights over plant materials is vital to encourage private sector investments in the seed sector.[4] This indicator measures the existence of a regulatory framework granting and protecting breeder's rights, the duration of the protections granted, the existence of discrimination between national and foreign breeders seeking protection, the availability of a list of protected varieties and the right to license protected varieties. In addition, the indicators cover access to materials essential for innovative breeding such as early generation seed developed by the public sector, germplasm stored in publicly managed genebanks, and genetic materials imported for research purposes.

Variety registration: The variety release process should ensure transparent rules for the release of hybrid seed of good quality and avoid unnecessary delays. This indicator measures how functional and inclusive the release process is, and the availability of information on new varieties. In particular, it covers the acceptance of testing data from foreign authorities, the composition of the variety release committee (VRC) and the existence and frequency of its meetings, and the availability and maintenance of an online variety catalogue. In addition, this indicator provides data on the time and cost involved for the private sector when registering a new maize variety with the government, from application to final release.

Seed quality control: The quality of seed is crucial for the adoption of new varieties by farmers. Only hybrid seeds of good quality can increase yields, ensure adaptability to climate change and therefore justify higher prices. The seed quality control indicator focuses on the quality control process that follows the release and multiplication of new varieties. It measures practices such as official fee schedules, the existence of a requirement to perform post-control tests, record-keeping to ensure traceability of breeding materials and labeling. Finally, this indicator measures the existence of third-party accreditation or self-accreditation to allow nonpublic sector actors to complement the government during the certification process.

How do countries perform on the seed indicators?

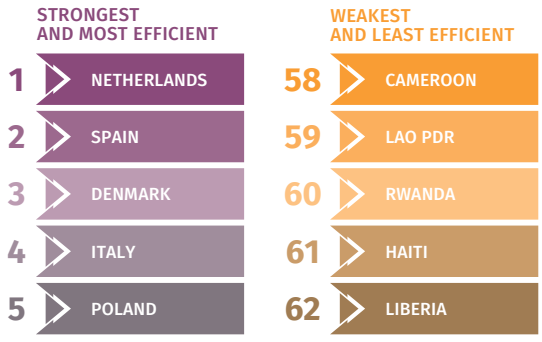
Overall, countries' performances across indicators are varied. Among the three indicators under the seed topic, the plant breeding indicator has the most regulatory good practices adopted across countries. Plant variety protection laws and registries are in place in countries with the strongest and least burdensome seed regulations such as the Netherlands and Uruguay, as well as in others with weaker seed laws such as Burundi,

Table 2.1 | What do the seed indicators measure?

PLANT BREEDING	• Existence, duration and terms of plant variety protection • Right to license protected varieties and availability of information on protected varieties • Access to germplasm, breeder and foundation seed
VARIETY REGISTRATION	• Legal requirements to register a new seed variety and information accessibility, including time and cost • Acceptance of testing data from foreign authorities • Variety release committee and availability of online variety catalogue listing registered varieties
SEED QUALITY CONTROL	• Breeders' requirement to ensure the traceability of breeding materials • Publically available fee schedule for certification • Third-party accreditation or self-accreditation for certification activities • Labeling requirements and penalties for mislabeled seed containers

Source: EBA database.

Table 2.2 | Where are seed regulations stronger and less burdensome and where are they not?



Source: EBA database.

Sudan and Tajikistan (table 2.2). In Burundi, a 2016 decree introduced a legal framework for the protection of plant varieties and created a register of protected varieties administered by the National Office of Control and Certification of Seed. Nonetheless, there is still room for improvement, even in countries with a topic score above the global average such as Georgia, which has adopted most of the regulatory good practices of the plant breeding indicators and the seed topic in general, but does not yet have a list of protected varieties available publically.

Overall, OECD high-income countries perform the best in the EBA seed indicators. Most countries have inclusive release systems. But in Greece and Poland nongovernmental representatives are underrepresented in VRCs. In addition, seed producers applying for registration in these countries need to comply with additional procedures after the VRC's decision to release the new variety. These additional steps affect the efficiency of their registration process, among the longest in the region. For most countries studied, additional efforts are required to have a strong and inclusive quality control process. It is less the case for OECD high-income countries, which have most of the regulatory good practices measured by the seed quality control indicator. Seed producers complying with mandatory certification have access to transparent costs and collaborate with the public authority to perform certain certification activities themselves. In Denmark, Italy and Spain, accredited seed companies perform their field inspections, sampling and lab testing and then label seed themselves. However, in Chile and Korea, plant breeders have not yet been required to retain records on the plant reproductive materials that they use.

Sub-Saharan African countries perform the lowest overall in the EBA seed indicators. Intellectual property rights are often neglected, as one-third of the countries in Sub-Saharan Africa do not grant any protection of plant materials or any access to germplasm conserved by public authorities. Regarding the region's registration process efficiency, more than one-third of Sub-Saharan African countries studied are not registering any improved seed[5] at all. The registration cost for a new maize variety in Sudan is among the highest across all countries studied, with an average cost representing 621% income per capita. Seed quality control processes lack transparency in the region since many countries do not have official fee schedules for certification activities that the government performs, and in nearly half of the countries, third-party certification is not permitted. Sub-Saharan African countries are closely followed by East Asian and Pacific and South Asian countries, whose performance on the seed indicators is also driven by a limited adoption of the regulatory good practices measured by the seed quality control indicator. However, several countries stand out within the Sub-Saharan Africa region with seed topic scores above the global average. In Kenya, for example, the legal framework provides tools for the protection of new varieties and access to early generation seeds and germplasms. The registration process is not restricted to the public sector and VRCs meet as often as necessary, which results in a registration time that is among the shortest across all countries studied. Furthermore, both Burundi and Rwanda adopted new legislation on the protection of plant varieties this year, which may lead to the creation of publically available registries.

What are the regulatory good practices?

Box 2.1 highlights regulatory good practices and some countries that implement these practices.

Allowing partnerships between the public and the private sector in the performance of seed-related activities

Scaling the formal seed sector is critical for countries wishing to increase the availability of hybrid seed of good quality.[6] To do so, private sector participation must be encouraged. In many countries, public research takes the lead in areas such as pre-breeding, germplasm conservation, and crop and resource management. Therefore, it is essential that the private sector has access to the outcome of public research as well as to the genetic resources that the public sector conserves, to support their own breeding efforts.[7] Seed companies can improve the production of breeder and foundation seed in the case of limited public capacity. Among the 62 countries studied, 38 allow private seed companies to produce breeder and foundation seed of local public varieties and to access germplasm conserved in public genebanks. For example, in Vietnam and Kenya, the law does not include any prohibition for the production of breeder and foundation seed, while in Guatemala, breeders wishing to produce them are required to sign an agreement with the *Instituto*

Box 2.1 | What are the regulatory good practices?

	REGULATORY GOOD PRACTICES FOR SEED	SOME COUNTRIES WHICH IMPLEMENT THE PRACTICE
PLANT BREEDING	Intellectual property rights over plant materials are granted and protected by law without discrimination based on the nationality of the applicant.	ITALY, ROMANIA
	Varieties subject to intellectual property rights are listed in a publicly available document.	CHILE, KENYA, POLAND
	Companies are not legally prevented from producing breeder and foundation seed of local public varieties.	UKRAINE, VIETNAM, ZIMBABWE
	Germplasms conserved in public genebanks are accessible to companies.	DENMARK, GEORGIA, SPAIN
	Intellectual property right over plant materials can be legally licensed to another party for production and sale of the variety.	EGYPT, ARAB REP., KOREA, REP.
	No government testing (other than phytosanitary) is required to import germplasm for the development of new varieties.	ARMENIA, UGANDA
VARIETY REGISTRATION	Testing results from foreign authorities are accepted as official data for registration purposes.	ITALY, MOZAMBIQUE
	A legally established variety release committee meets regularly and balances public and private sector participation in the evaluation and registration of new varieties.	KENYA, SPAIN, URUGUAY
	An up-to-date variety catalogue is available online and includes agro-ecological zones suitable for each variety listed.	NIGERIA, PERU
	Variety registration is efficient and affordable.	KOREA, REP., THAILAND
SEED QUALITY CONTROL	Official fee schedules are available for certification activities that the public authority performs.	CAMBODIA, CAMEROON
	Plant breeders are required to ensure the traceability of their plant reproductive materials for at least two years.	BURUNDI, SERBIA
	Private seed companies and/or third parties may be accredited to perform certification activities.	RUSSIAN FEDERATION, ZAMBIA
	A percentage of certified seed is subject to post-control tests by the national seed authority yearly, and seed is removed from the market if standards are not met.	GHANA, MOROCCO
	The law requires the labelling of seed containers and provides for a penalty for the fraudulent sale of mislabeled seed bags.	BOLIVIA, INDIA, JORDAN

Source: EBA database.

de Ciencia y Tecnología (ICTA). In Benin, Burkina Faso, Cameroon, Lao PDR, Nicaragua and Peru, public research and genetic resources that the public sector conserves are not accessible to the private sector.

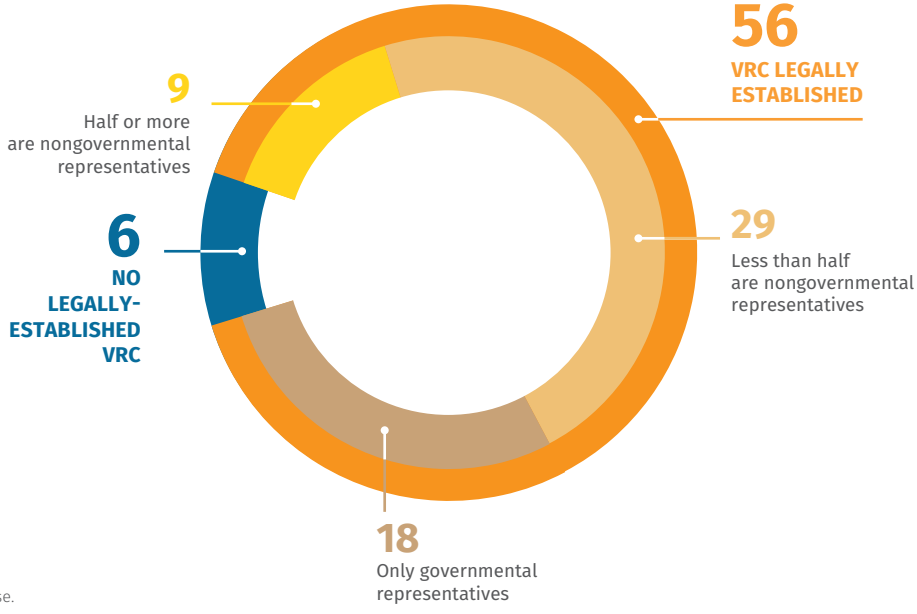
Partnership between the public and private sectors should not stop with breeding. The VRC is responsible for testing new varieties for registration and approving it for further commercial production and distribution. To ensure that testing criteria are developed by all stakeholders, nongovernmental representatives (associations of seed companies, nongovernmental organizations [NGOs] or farmer associations) should be included in the VRC routine operations. Among the 62 countries studied, 38 countries require the participation of nongovernmental representatives when deciding whether to release a new variety or not (figure 2.1). Among these countries, nine require an equal or higher number of nongovernmental representatives over governmental ones. In the Netherlands, for example, the largest seed producer in Europe and where there are more than twice as many nongovernmental representatives compared with public sector representatives in the VRC, the time to register a new variety is among the shortest across countries. In Denmark, the largest exporter of seed globally, only one of the 11 members of the VRC is a government representative. In contrast, Ethiopia, Mexico and Russian Federation, which do not have associations of seed companies, NGOs or farmer associations in their VRC, have among the longest registration time.

In many developing countries, the lack of personnel and other resources lead to long delays in seed certification and testing, which impede the delivery of certified seed to farmers in a timely manner.[8] Laws can allow the accreditation of private laboratories, private inspectors and university centers to lessen the burden on the public sector. Among the 62 countries studied, 36 countries have laws that allows private seed companies and third parties to be accredited for certification activities usually performed by the national authority. In Romania, since 2002, individuals and seed companies can be accredited to carry out field inspection and sampling, to test seed quality and to issue certification documents under Ministry of Agriculture supervision. The accreditation is subject to training and to compliance with standards that the Ministry sets. In Cambodia, Nigeria and Sri Lanka, as well as in 16 other countries—mainly low-income and lower-middle-income countries— only the national authority can perform the mandatory certification.

Implementing regulatory good practices

The ideal regulatory environment for the seed sector is a clear legal framework supported by functioning institutions and efficient procedures. The law establishing institutions and granting rights should be enforced in practice. Similarly, practices implemented without a legal framework may not always be beneficial to all seed sector actors in the absence of clear implementation criteria. Among the 45 countries where public research institutes license public varieties to seed companies for production and sale, 13 countries do so in the absence of clear rules. In 2016, the Institute for Environment and National Research in Burkina Faso (INERA) designed a framework agreement on future public-private partnerships for the production of initial classes of seed.

Figure 2.1 | Nongovernmental representation in variety release committees (VRCs)



Source: EBA database.

The release process for a new variety is prescribed in the country's seed law and usually involves an evaluation of the new variety through testing, review of the result by a decision body and registration in an official catalogue. Among the 62 countries studied, 56 establish a VRC tasked with reviewing the test results of any new maize variety, before its registration and release. In Benin, Bosnia and Herzegovina, Burkina Faso, Cambodia, Mali and Rwanda, the VRC provided for in the law does not appear to meet in practice, while they are a prerequisite to the availability of seed in countries where registration is mandatory. With the exception of few countries such as Georgia or Italy, where regulatory good practices go hand-in-hand with a streamlined and low-cost variety registration process, a large number of countries have adopted lengthy procedures that are likely to result in delays in seed delivery to the farmer.

Fourteen countries, most of them in Sub-Saharan Africa, do not have any private seed companies registering new maize varieties, despite appropriate regulations being in place. In Niger, the seed law establishes a strong regulatory framework, which includes a VRC with the participation of all stakeholders and meetings on a quarterly basis, as well as a variety catalogue available online. However, the country still has no private seed companies that register new maize varieties.

In a number of countries, VRCs are functioning with varied stakeholder participation and regular meetings but the registration process is still burdensome to seed producers because of its length or cost (figure 2.2). For example, in Nicaragua the registration regulatory requirements follow most of the good practices identified. The VRC is functional, meets monthly and does not require additional procedures to release the new variety after its decision. Despite these regulatory good practices, however, the variety registration process in Nicaragua is the third most expensive across all countries, equivalent to 787% income per capita, and has the sixth lengthiest procedure that lasts 650 calendar days.

Certification processes designed to ensure seed quality have been identified as having a negative effect and as impeding the development of the seed supply chain,[9] due to delays in the government's performance of certification activities. Accreditation mechanisms are intended to allow seed companies or third parties to assist the public authority in certifying seed. Among the 62 countries studied, more than half of them have created a legal framework for third party or self-accreditation. However, only 31 countries accredit individuals or companies for field inspections, sampling, lab testing or labelling. For example, in Armenia, Serbia and Uganda, seed companies or third parties have not been accredited despite the existence of regulation.

Ensuring seed quality in the market

Regulations establish mechanisms that guarantee farmers' access to hybrid seed of quality for their crop production. Hybrid seeds, when used properly and together with other inputs like fertilizer, have proven to increase farmers' yield by 12–15%.[10] A registered seed's genetic purity, identity and a given minimum quality level must be found in the seed sold if that seed is ultimately to reach the farmer's fields and improve

Figure 2.2 | Few countries have both strong registration regulations and an efficient registration process

Source: EBA database.

Farmers harvest their crops near Kisumu, Kenya. Photo: Peter Kapuscinski / World Bank.

yields. Research has shown that farmers will not adopt new technologies such as improved seed varieties when they do not expect any economic return due to low-quality seed.[11] Post-control tests assess the quality of certified seed to verify that the seed's varietal purity has been maintained. Among the 62 countries surveyed, half of them require the performance of these tests whether in the field or in laboratories. Among them, 10 countries have seed laws that require the national authority to test a minimum percentage of certified seed annually (Burundi, Denmark, Ghana, Greece, Morocco, the Netherlands, Poland, Romania, Spain and Turkey).

Labelling standards and sanctions for the fraudulent sale of mislabeled seed containers can also improve seed quality at the retail level. A labelling system allows farmers to know what they are buying and from whom, making producers and distributors accountable for the seed container content. Standardized labels can improve farmer's confidence in the seed in circulation. Among 62 countries studied, 5 do not have a legal requirement to label seed containers for sale. Most of them require labels to include the producer name and address, the crop name, the class of seed and the minimum germination percentage, which is necessary for the farmer to make an informed decision on which variety to purchase. Other information such as the production year, the minimum purity percentage or the existence of a chemical treatment may also be required, such as in Ghana, Mexico or Zimbabwe. By contrast, more than half of the countries studied do not require labels to include information relating to repacking or relabeling of seed containers. Repacking and relabeling information allows the buyer to retrace certified seeds to their seed lots. Finally, a large majority of countries have seed laws that include a penalty for sale of mislabeled seed to discourage the circulation of fake seeds.

Conclusion

Introducing and implementing seed quality and assurance are challenging. This process requires a robust legislative framework, sufficient financial resources, well-trained inspectors, capable laboratories and relevant legal mandates to conduct post-control tests and market inspections. Countries that implement such systems take a significant step towards a more competitive and commercially-oriented agricultural sector that has access to improved varieties and increased crop yields. Moreover, such countries reduce the risk of fake and low-quality seed entering the market, which can otherwise undercut crop yields and lead to reduced food supply or even shortages.

NOTES

1 Bold et al. 2015.

2 Keith Virgo 2016.

3 Fita et al. 2015.

4 Fernandez-Cornejo. 2004.

5 Only maize seed is considered for the hypothetical case study assumption used to standardize the variety registration indicator.

6 Prabhala et al. 2015.

7 Bishaw and van Gastel 2009.

8 USAID 2016.

9 Smale et al. 2011.

10 Abate, de Brauw, Minot and Bernard 2015.

11 Bold et al. 2015.

REFERENCES

Abate, Gashaw Tadesse, A. de Brauwm, N. Minot, and T. Bernard. 2015. *The Impact of the Use of New Technologies on Farmers' Wheat Yield in Ethiopia: Evidence from a Randomized Controlled Trial.* IFPRI Discussion Paper 01462. International Food Policy and Research Institute, Washington, DC.

Bishaw, Zewdie and A. J. G. van Gastel. 2009. "Variety Release and Policy Options." In *Plant Breeding and Farmer Participation*, edited by S. Ceccarelli, E. P. Guimarães and E. Weltizien, 565–88. Rome: FAO.

Bold, T. et al. 2015. "Low Quality, Low Returns, Low Adoption: Evidence from the Market for Fertilizer and Hybrid Seed in Uganda." Kennedy School Faculty Research Working Paper Series. Harvard University, Kennedy School, Cambridge, MA.

Fernandez-Cornejo, J. 2004. "The Seed Industry in U.S. Agriculture: An Exploration of Data and Information on Crop Seed Markets, Regulation, Industry Structure, and Research and Development." United States Department of Agriculture, Washington, DC.

Fita, A., A. Rodríguez-Burruezo, M. Boscaiu, J. Prohens and O. Vicente. 2015. "Breeding and Domesticating Crops Adapted to Drought and Salinity: A New Paradigm for Increasing Food Production." *Frontiers in Plant Science* (6): 978, November. doi: 10.3389/fpls.2015.00978.

Prabhala, Pr. et al. 2015. "Early Generation Seed Study." Bill & Melinda Gates Foundation for the United States Agency for International Development (USAID). USAID, Washington, DC.

Smale, M., D. Byerlee and T. Jayne. 2011. "Maize Revolutions in Sub-Saharan Africa." World Bank Policy Research Working Paper 5659. World Bank, Washington, DC.

USAID (United States Agency for International Development). 2016. "Southern Africa Regional Seed Sector Assessment." USAID, Washington, DC.

Virgo Keith. 2016. *Correspondence*, December 20. United Kingdom.