Production quality controls in farmer seed systems in Africa

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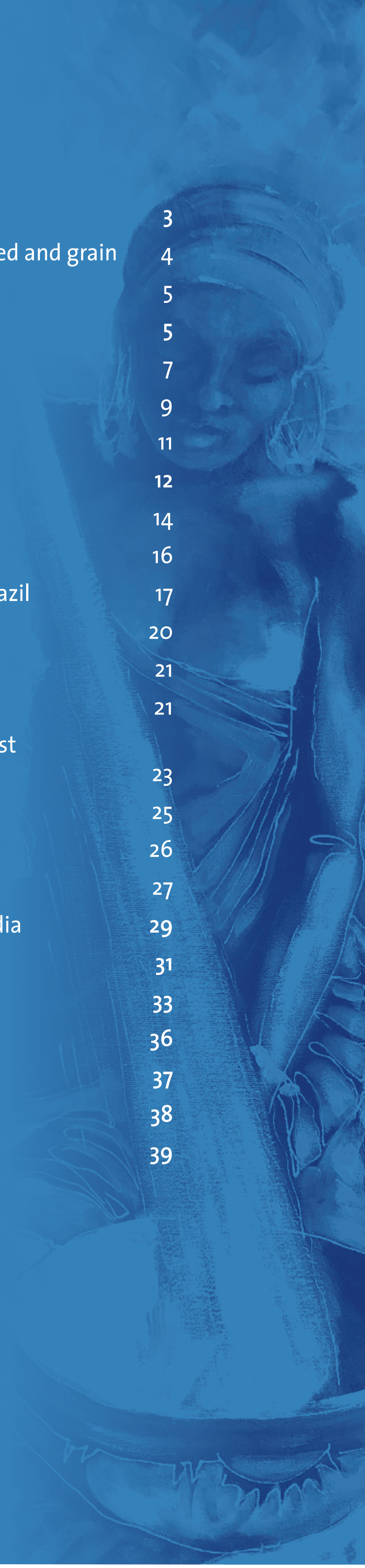
Contents



On 7 April 2015 the African Centre for Biosafety officially changed its name to the African Centre for Biodiversity (ACB). This name change was agreed by consultation within the ACB to reflect the expanded scope of our work over the past few years. All ACB publications prior to this date will remain under our old name of African Centre for Biosafety and should continue to be referenced as such. We remain committed to dismantling inequalities in the food and agriculture systems in Africa and our belief in people's right to healthy and culturally appropriate food, produced through ecologically sound and sustainable methods, and their right to define their own food and agricultural systems.

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www.acbio.org.za
PO box 29170, Melville 2109, Johannesburg, South Africa. Tel: +27 (0)114861156

Researched and written by Stephen Greenberg with early contributions by Sasha Mentz-Lagrange
Proofing: Liz Sparg
Layout: Adam Rumball, Sharkbuoys Designs
Graphics: Adam Rumball
Cover image: Helen Day

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Introduction

Quality seed is recognised as a significant contributor to smallholder productivity and is estimated to contribute up to 50% of plant performance, though it must go hand in hand with soil quality. Seed is one of the easiest and most effective places to start when seeking to increase productivity.[1] However, quality means different things to different people. Quality refers both to the preferred traits of a seed variety or population, which vary depending on the user and the context, as well as the ability to retain and transfer these traits intact to the user in the seed production process. The main focus of this report is on the latter, that is, how seed is quality managed in the production and distribution process, and what assurances are given to the buyer that these processes have been adequately followed.

The formal sector has a well-established system for maintaining seed quality through production and dissemination processes. However, in many parts of the world, including Africa, the formal sector only provides a minority of the seed farmers need. Formal sector quality criteria mostly are developed at a distance from farmers and do not always adapt well into specific production contexts. Conversely, farmers reproduce and exchange a large share of seed across many parts of the world, in particular Africa, Asia and Latin and Central America. Farmers have a range of diverse practices for ensuring that seed quality is retained over time. Nevertheless, farmer seed systems are not perfect. Quality controls in smallholder seed production systems are unevenly practised, drought and other difficult production conditions may limit reproduction and maintenance of quality seed, and there are intense pressures on farmers to abandon their diverse crops and varieties in favour of a smaller number from the formal sector that offer potential for cash generation.

This report starts from a base of criteria that have emerged over time in the formal sector, viz. genetic (identity and purity), physiological (germination and vigour), analytical (minimisation of off seeds and non-seed materials) and sanitary (disease-free seed) quality. These do cover important elements of seed quality. However, as formulated in the formal sector, these criteria may not be entirely appropriate for farmer seed production.

There is appreciation of the central role of farmers – especially smallholders – in biodiversity maintenance, conservation and use. This role is recognised as centrally underpinning farmers' rights, as elaborated in the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA) for example, and in concepts of ecosystem services and multifunctionality in agriculture, even though these latter terms may be abused to commodify these services. However, farmers' ongoing activities are part of a wider ecological system that is not in good health. In 2009 researchers at the Stockholm Resilience Centre (Rockström et al., 2009) identified biodiversity loss as far exceeding the planet's safe operating boundaries, even to a greater extent than climate change, which, itself, is in a critical situation. According to the authors, "the current and projected rates of biodiversity loss constitute the sixth major extinction event in the history of life on Earth—the first to be driven specifically by the impacts of human activities on the planet" (Rockström et al., 2009:14). Fowler and Mooney (1990) have shown dramatic genetic erosion in advanced capitalist and peripheral countries alike, since the rise of industrial agriculture. This points to an increasing fragility in global food supply, with the potential for catastrophe. Alternatives to industrial agriculture with centralised control are required. From an agricultural biodiversity and seed point of view, smallholder farmer maintenance, enhancement, use and sharing are core aspects of such alternatives.

1. Discussion with Marien Valstar, Senior Policy Officer Seeds and Propagating Materials, Netherlands Ministry of Agriculture, Nature and Food Quality, Den Haag, 15 October 2018

Terminology: Genetic materials, planting materials, germplasm, seed and grain

Different people use each of these terms differently. Here we are not specifying the 'correct' use of the terms but just making it clear how we are using these interconnected concepts in this paper. The glossary at the end of the paper provides definitions for other commonly used terms.

- 'Genetic materials' refers to the whole pool of biodiversity.
- 'Germplasm' refers specifically to genetic materials that are selected for further (formal sector) breeding work. These materials are often available only in small amounts and mostly found in gene banks.
- 'Planting materials' refers to genetic materials developed over time and space, and used for planting for production (including the production of seed).
- 'Seed' is used interchangeably with 'planting materials', and includes vegetatively propagated materials. 'Seed' refers to that genetic material which farmers use to grow plants (or livestock) for production. It includes 'varieties' as defined in the formal system, as well as 'populations' in farmer seed systems.
- 'Grain' is the production output for food or feed. Farmer seed is often referred to (in a dismissive way) as grain, based on the argument that it is not especially selected for seed but is just randomly taken from the grain supply for replanting. It is a misnomer because a lot of seed is not of grain crops, but this merely reveals the bias towards grain crops prevalent in Green Revolution approaches. More importantly, this argument does an injustice to the detailed and knowledge-intensive farmer practices in continuously selecting, crossing and adapting the genetic materials at their disposal in the field, as well as farmer experience in identifying good materials for use in planting.

Farmer selection specifically for seed may occur at various points in the production cycle (Figure 1). First, local product markets are undoubtedly a source of seed for farmers (McGuire and Sperling, 2016), but this does not mean that farmers indiscriminately buy grain and merely take a portion for seed without any further thought. Selection at the market can be based on visual characteristics (e.g. desired traits, product health) and interaction with the seller. Second, seed could also be selected at home from products from the market and other outside sources, including the farmer's own harvest from the field. Third, many farmers will deliberately select plants for seed in the field, even from an early stage of production. It is true that there may be some 'negative selection' (e.g. using leftover crops for seed after harvesting the good crops) but definitely this is not the only practice. Undoubtedly selection skills are unevenly distributed, but certainly the majority of Africa's farmers would not have survived tenaciously on agricultural production all these years without accumulating useful knowledge about what works and what doesn't.

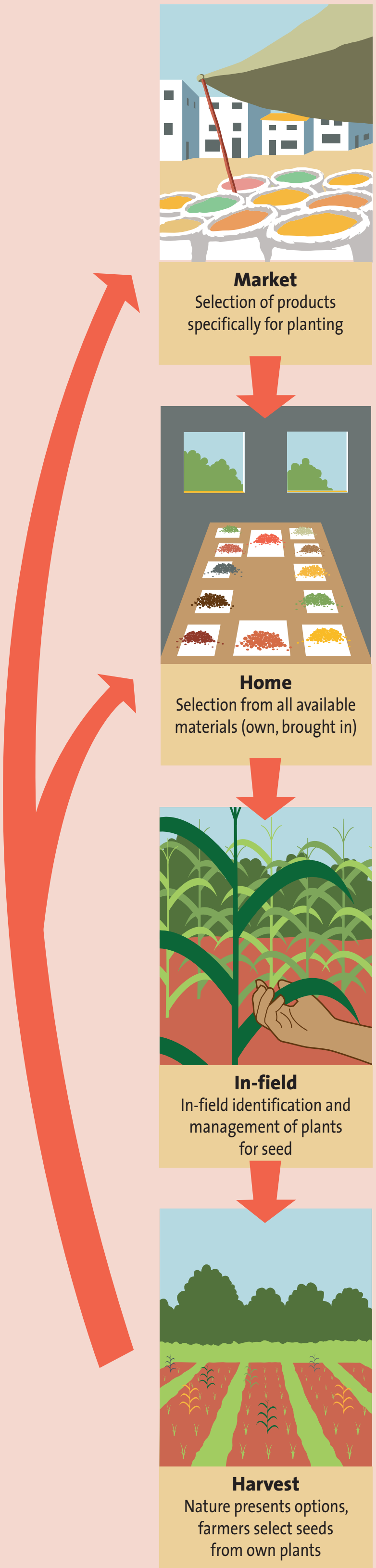

Figure 1: Four points of possible farmer seed selection

As seed and food sovereignty movements grow, and there is increased urgency to develop practical alternatives to extractive industrial agriculture, issues of farmers' independent variety development, production and distribution have arisen as practical considerations. This paper is intended as a contribution to this movement. It considers what quality controls (QC) smallholder farmers are practising in their own systems, looks at obstacles to effective quality control functions in these systems – both internal (e.g. poor agronomic practices) and external (e.g. seed policies and laws, climate change) – and reflects on support options to strengthen these practices without imposing a rigid formal structure designed for different purposes. The intention is to report on and share findings and reflections with farmers, practitioners and activists, and amongst decision-makers in governments and institutions working on seed.

Structure of paper

The paper starts with a framing of seed systems and seed production as a continuum from formal/commercial through quality declared seed (QDS) and intermediate systems and to farmer seed practices and materials that are widespread but not formally codified or recognised. It then goes through the elements of quality before defining and discussing quality control (QC) and quality assurance (QA) practices and procedures in intermediate and farmer seed systems. On QC, case studies from East Africa and Brazil are drawn on to highlight innovations and challenges. On QA, participatory guarantee systems (PGS) are considered as an option for farmer seed systems. Key issues, constraints and elements of success in farmer seed production are considered, and the paper concludes with some policy implications.

Seed systems and seed production

Table 1 indicates a continuum in the seed system from formal, via QDS and intermediate systems, to farmer seed systems across three variables: source of planting materials, QC and QA. At one end of the spectrum is the formal system characterised by registered seed varieties, and defined formal production standards and quality assurance procedures. In this paper we use the terms 'formal' and 'commercial' relatively interchangeably, because formal procedures for seed production have developed together with commercialisation of seed production, whether in Europe or Africa or elsewhere. It is difficult to prise the formal and the commercial apart, since the technical procedures of formal breeding are embedded in the commercial production model. This has resulted, over time, in the separation of specialised breeding processes from farmers, who have become a market for externally produced inputs.

'Formal' refers to the technical and governance procedures, systems and structures designed for and supporting commercial seed breeding, production and distribution. The formal system aims to produce and disseminate quality seed, based on agreed external standards for commercial use, and operating through private companies, research institutes and universities. QDS is part of the formal system and is also based on registered varieties and defined standards for QC and QA, although with a few relaxations, such a fewer inspections. Registration and certification are both part of the formal system.

Table 1: Seed system continuum

System	Variety	Quality control	Quality assurance
Formal	registered	defined external standards	defined procedures
Quality Declared Seed (QDS)	registered	defined external standards	defined procedures, with minor relaxation (e.g. fewer inspections)
Intermediate	registered	farmer-based	voluntary
Farmer	own	farmer-based	voluntary

'Commercial' essentially refers to the scale of production, with the 'commercial seed system' referring to specialised seed production in commercial volumes. Defining what is commercial and what is non-commercial is a key issue, since exemptions in seed laws are very often based on 'non-commercial' activities. The threshold between 'commercial' and 'non-commercial' would be defined in national regulations and is directly related to exemptions from plant variety protection (PVP) and seed quality laws. For our purposes, 'non-commercial' is understood to incorporate a wide range of sharing and exchange practices, as well as sales but below a threshold as defined in specific contexts and regulations. There are different possible ways of measuring this threshold, for example using household income (relating the threshold to average incomes in a country or area), production practices, land size, volume of production or turnover. The main challenge for measures such as land size or volume of turnover is that these will vary by crop type and production region and will therefore need specific and different thresholds for every crop, rendering the system unwieldy and difficult to implement in practice. Annual turnover may be a good candidate, since it is a measure of business size, and in this context the commercial threshold could be related either to the seed business on its own, or to the entire agricultural enterprise.[2] The threshold could be set at a relatively high level to allow for unimpeded growth from below. Most smallholder farmers will not record their turnover in detail and could be automatically exempted. With regard to protected varieties, the onus should be on rights holders or the state to prove that farmers are producing at commercial scale where there is disagreement.

There are some areas where formal and commercial are not identical, in particular in relation to the source of planting materials. For example, public sector varieties produced through the formal breeding system might not only be sold commercially. As shown later in this report, they might also be multiplied and/or distributed for free to farmers for unregulated further use to improve access to quality seed, through the public sector, non-government organisations (NGOs), or development aid/emergency relief programmes.

Intermediate systems differ from what we are calling farmer seed systems primarily in the source of planting materials for seed production. In intermediate systems, seed comes from the formal sector but is simply shared with farmers through the public sector, NGOs or aid programmes and there is no further monitoring or regulation of use. Farmers are free to multiply and share or sell to others. The main purpose is to rapidly disseminate new planting materials to farmers for use. Intermediate systems may also incorporate a commercial element, using formal sector QC, but this is not a defining feature. This intermediate model is fairly common in Africa under the rubric of community seed production.

Farmer seed systems refer to practices of biodiversity conservation, selection, adaptation, use and exchange outside formal processes. These are often termed 'informal', which is applicable if formality is defined in terms of externally defined rules and governance over production practices. Seed comes from farmers' reproduction and reuse of seed in their possession. This is primarily landraces/farmer seed, but can include formal sector varieties that have entered the production system and are being reused and adapted according to natural and farmer selection. This could even extend to the reuse of hybrids. Although hybrids generally do not perform well after first use, on occasion they are known to retain some valuable traits for farmers on reuse. QC is farmer-based and QA is voluntary in intermediate and farmer systems, as we are deploying these terms here.

In principle, seed from the farmer system can also become available for commercial sale defined by a threshold of production, as indicated earlier. However, to do so,

2. It is not clearly established in most seed laws based on the International Union for the Protection of New Plant Varieties (UPOV) whether 'non-commercial' activities refer only to seed production or if they refer to the entire agricultural enterprise.

they must meet the requirements in formal seed laws designed for commercial breeding and production. This raises the question of whether there should be any special dispensation or flexibility even after (smallholder) farmers have gone past the commercial threshold in seed production. This is discussed further in the paper. It may be that to enter fully into the commercial system, farmer varieties and populations will need to be registered and formal QC will need to be adopted. This, then, takes such varieties outside the farmer system and into the formal system, albeit based on materials originating with farmers. This is a point of integration between farmer and formal/commercial systems. This also raises the question of whether farmers' heterogenous populations can be accommodated within the commercial framework of varieties. If not, farmers may be excluded from commercially selling their good quality farmer seed merely because of definitional limitations in the law.

What do we mean by seed quality?

(This section is drawn from Almekinders and Louwaars, 1999:87–93 unless otherwise specified)

Quality is socially constructed, meaning human beings decide what constitutes quality, and this definition varies over time and space. In this paper we start with the quality framework developed over many years in the formal sector. As a set of elements this provides a useful launching pad for the discussion on QC for farmer seed, although there are some limitations, especially in the procedures for implementing controls to manage these, discussed later.

Genetic quality refers to maintaining the desired characteristics of the selected seed in the production process, e.g. short cycle, yield, tolerance to stresses such as drought or low fertility, resistance to pests and diseases, tastes or market requirements, etc. Genetic quality is structured on the basis of 'varieties' as defined in the formal system. By definition, these are static, capturing a set of characteristics that is not meant to change over time unless a new variety is created. This cannot capture the inherent heterogeneity of farmer seed populations, that are dynamically adapting to production conditions and selection pressures over time. Maintaining varietal identity and purity in seed production is about ensuring that the selected characteristics are identified and transmitted intact – or with as little degeneration as possible – to the user, the farmer who will plant the seed.

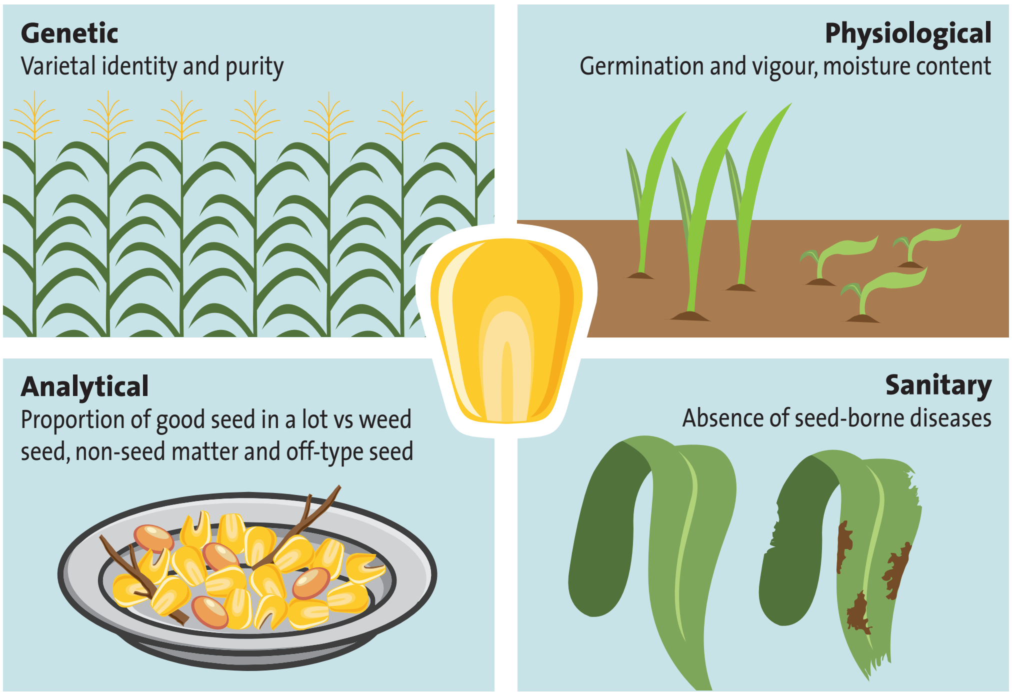

Figure 2: Four key elements of seed quality

Genetic degeneration can occur in the field as well as after harvesting. In the field, this can happen through crossing with types you don't want, or with diseased or off-type plants, or through a build-up in negative mutations. This is mainly a result of poor selection procedures or lack of controls in the field (Agriinfo, 2015). The genetic structure of the plant is at its peak usually at physiological maturity (when the grain or product has reached maximum weight and yield), or sometimes at harvest. Thereafter genetic degeneration may take place if the seed is not appropriately handled and stored, for example through mixing or exposure to diseases.

> genetic degeneration may take place if the seed is not appropriately handled and stored

Genetic purity is tied into formal sector plant breeding[3] and the way in which varieties are defined on the basis of fixed and measurable characteristics, using the distinct, uniform and stable (DUS) criteria. 'Distinct' means the variety is different in at least one essential characteristic from other existing varieties in use. 'Uniform' means different plants grown from the seed will have the same essential traits as one another. 'Stable' means the essential traits that define the variety will be faithfully reproduced when the seed is grown. These are important for commercial purposes for farmers who are buying the variety to be able to know what to expect, and also to indicate what is specific about one variety over another.

However, there are questions about whether the DUS criteria adequately incorporate farmer seed, where seeds are genetically heterogenous and continuously adapting over time to the local conditions, with farmer assistance (Halewood, 2016). These qualities of adaptability and genetic variability may be essential characteristics sought in seed especially for use in stressed conditions. Even uncontrolled crossing in the field does not automatically mean genetic degeneration, as evolutionary breeding processes show (Cenesta, 2013; Rahmanian et al., 2014). At the same time, it is possible for farmer varieties also to lose some desired characteristics because of degeneration through crossing, or through poor selection procedures (whether in the field or at the market).

> qualities of adaptability and genetic variability may be essential characteristics sought in seed

Physiological quality refers to the seed life. The seed should germinate, and the seedling must be strong enough to withstand the environmental conditions it faces when emerging. Vigour testing is a stress test that checks performance in sub-optimal conditions. Germination rates and vigour usually go together.

Moisture and temperature control in storage are critical QC elements. Moisture content determines how long the seed will remain viable. It varies by crop, but the range is mostly 8–13%. It should not be more, otherwise the seed can sprout or rot. Harrington's rule states that a one percentage increase in seed moisture content reduces the storage period by half (conversely, a one percent decrease doubles the storage period), and that a five degree Celsius increase in storage temperature reduces the storage period by half (a five degree Celsius decrease doubles the storage period). Insects and moulds increase as the temperature increases. This can be dealt with through early harvesting, well-dried seed, and dry and cool storage conditions (Almekinders and Louwaars, 1999:113).

Analytical quality refers to the amount of good seed in a lot. There should be little or no non-seed matter (e.g. stones, sticks) amongst the seed. This is more an issue for mechanical processes, and hence commercial production, but even farmers who plant by hand will not want to

3. 'Plant breeding' refers to formal sector breeding processes. Related terms in farmer systems are 'crop improvement', 'enhancement', 'selection' and the wider 'biodiversity conservation, adaptation and use' (see ACB, 2018).

Registration of farmer varieties

Before a variety is multiplied in the formal sector for distribution, it usually must go through a registration process with some tests. The formal system of registering seed varieties has developed and become codified over many years, with the objectives of: i) transparency in the market, to protect farmers from misrepresentation by linking variety names to well-described varieties with particular agronomic and use values; ii) provision of information to farmers about the variety and its characteristics; and iii) increased agricultural production through availability of improved varieties (Louwaars and Burgaud, 2016:189, 208). In essence, registration aims to protect the farmer as buyer, and provide information and relative certainty about the characteristics of the varieties on offer. Registration provides a guarantee underwritten by a reputable authority.

Variety registration is based on an official application, starting with a form giving information that may include details of the applicant and variety, the name and origin of the variety, a simple morphological description for identification purposes, indication of the agroecological zone for which the variety is suited, information about procedures to be followed for maintaining the variety, previous applications in other countries and results of these applications, and seed treatment. A sample of the planting material accompanies the form. Once the application is received, trials are conducted to test the variety and compare it with other existing similar varieties, both to see if it is different, and if it has the characteristics indicated in the application. This usually incorporates DUS tests, and in some places also value for cultivation and use (VCU) tests.

VCU tests are based on the notion that new varieties must have some additional benefit over existing varieties before it can be accepted. In some countries, such as the US and South Africa, this is not required. A variety can enter the market even if it does not outperform existing varieties, with market forces shaping its fortunes. Trials are often conducted by the registering authority, but in some cases the applicant can do the tests themselves and provide the results to the authorities. Results from tests by appropriate authorities in other countries may also be used. In some cases, the registering authority may also waive these requirements. DUS and VCU tests are usually conducted at the same time over two to three years in multiple locations. Registration is compulsory in most countries, but in others, again such as the US, it is voluntary and seed is released on the basis of truthful labelling.

Registering authority approves or declines the application based on the test results

If approved, the variety is entered onto the national list and can be multiplied and sold commercially

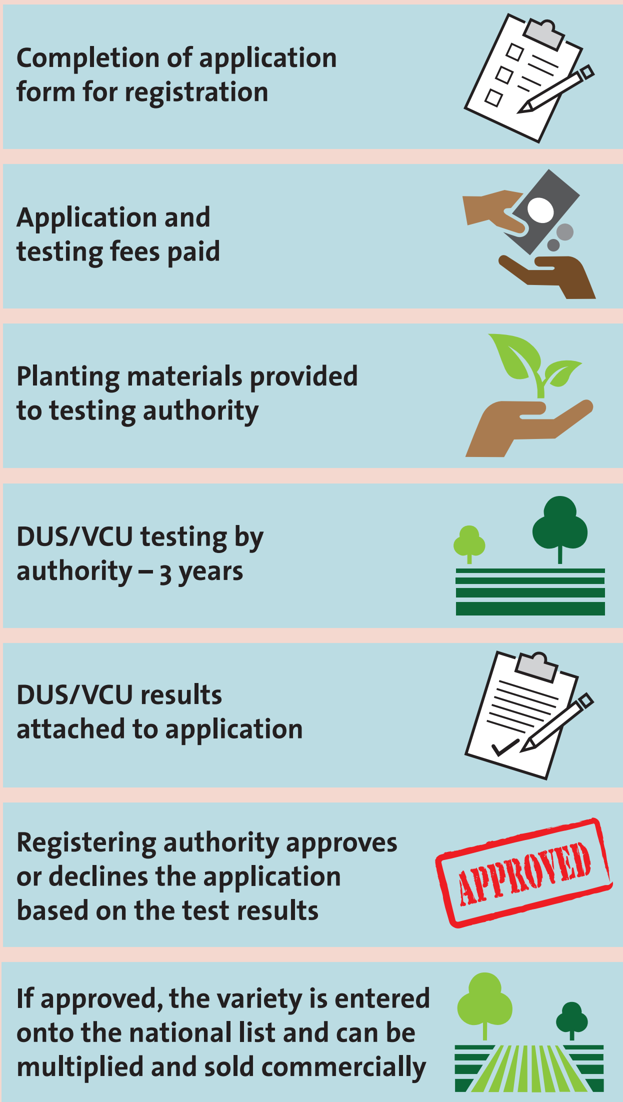

Figure 3: Steps in variety registration and release

With increasing recognition that farmers have their own seed populations and are mostly exchanging these seeds outside the formal system, there has been a growing discussion about whether farmers should register their seeds. In the existing formal framework, if farmers plan to register their seed, they will need to fix the characteristics into a defined variety. Registration can open farmer seed to commercial exploitation with uneven allocation of benefits and costs, especially when there are no free, prior, informed consent (FPIC) or access and benefit sharing (ABS) arrangements. On the other hand, there are reasons why farmers may want to register their seed, especially in the context of seed laws that require registration before a variety is legally recognised and can be sold. These include:

- Recognition of farmer seed in order to open space for public sector support to maintain and enhance this seed;
- Defensive publication to establish farmer populations/landraces as 'prior art' to prevent biopiracy, i.e. to prevent others from claiming intellectual property (IP) protection on the varieties;
- Commercialisation (sales above a threshold) and cross-border trade; and
- Farmers desiring to claim their own IP protection on varieties.[4]

However, existing seed laws in most places – especially those based on compulsory variety registration – are designed for standardised and uniform varieties for commercial use. Regulations are not well suited to farmer populations in all respects. In particular, the requirements for uniformity and stability do not accommodate the genetic heterogeneity of farmer seed populations, which mostly are constantly adapting to changing environmental conditions. Registration (including seed business registration) may be costly for smallholder farmers, and centralised testing facilities are inaccessible and often under-resourced and lacking in capacity. These regulations mean farmers may often be excluded from registering their seed, even if these seeds display valuable characteristics.

Two primary approaches are available to accommodate farmer seed populations in formal registration systems:

- Complete exemption from registration for non-commercial or local use and exchange between farmers; and
- Flexibility/modifications to existing regulations and requirements.

Exemption for farmer seed below a commercial threshold of sale is an option that allows farmers to work on their seed and to exchange or sell it between themselves or in their localities without undue constraint. In Brazil the seed law explicitly forbids restrictions on the inclusion of farmer seed in publicly funded programmes (Santilli, 2016:342). Ethiopia and Brazil have adopted this approach, while also recognising farmer varieties.

However, lack of registration could leave farmer seed exposed to potential biopiracy. This is one of the main reasons for farmers to register their seed. A number of countries have adopted some form of flexibility to make it easier for farmers to register their own seed populations. These countries include Peru, Ecuador, Costa Rica, Benin, France, Italy, Netherlands, Finland, Switzerland, Nepal and Republic of Korea (Halewood, 2016). An example of flexibility is parallel registration lists with alternative criteria.

4. We do not go into a detailed discussion here of the pros and cons of farmers claiming exclusive IP rights on existing materials, except to say that, generally speaking, such rights run counter to the culture of sharing and exchange that has characterised farmer-to-farmer interactions historically, and to the notion of genetic resources as a common heritage. Farmers' collective roles in maintaining and developing these materials for use can be met through ABS mechanisms and conservation funds that support ongoing farmer activities in maintaining and enhancing genetic materials. There can also be FPIC requirements, although unanswered questions remain about from whom, precisely, consent should be sought.

In Benin, a special register for farmer seed allows for registration on the basis of VCU tests alone. These seeds can be produced and sold (ISSD Africa, 2017a:8). "Special registers and respective labelling requirements may be a much better solution than certification schemes which simply ban everything from the market that does not comply with the DUS requirements" (Leskien and Flitner, 1997:54). In some countries, registration and testing fees are reduced or covered by the state. In Peru, DUS/VCU is not required for registration of farmer seed on the basis that value has largely been proven by the years of cultivation in farmers' fields. Certification is also free of charge and does not have to be renewed (Noriega, 2016:235).
In Nepal, i) regulations enable farmers to use qualitative data based on their traditional knowledge of the landrace in their application for registration, including major traits of the seed obtained through a preference ranking, consisting of aroma, flavour, texture and cooking qualities; ii) the requirement for cultivation data from several different locations in the country and for multiple years of production has been removed, and just one location and one year's yield performance is required; and iii) uniformity criteria are relaxed (Fadda, 2016:69).

In Brazil, requirements for registration of farmer seed are as follows (Santilli, 2016:343–4):
i) They must be developed, adapted and produced by family farmers, agrarian reform settlers or traditional and indigenous populations and communities;
ii) They must have phenotypical characteristics that are well established and recognised in these communities;
iii) They must have been in use by farmers in one of these communities for more than three years;
iv) They cannot be developed by means of genetic engineering or have evolved from hybridisation processes that are not controlled by local family farmer communities;
v) They are not eligible for patents, ownership or any form of private protection, meaning there can only be collective and non-exclusive rights.

There may be some practical constraints to registering farmer seed even where flexibility is granted. A challenge for defensive registration (to prevent others from claiming IP rights over farmer varieties) is to identify efficient measures to establish prior art for landraces (Andersen, 2016:149). Another is that data on seed is seldom systematically gathered (Fadda, 2016:70). The large number of farmer seed populations that have resulted due to the vast ecological diversity within countries, in combination with the limited efficiency of variety registration due to insufficient human and technical resources may make registration of farmer seed impracticable (Louwaars and Burgaud, 2016:208).

pay for useless materials if they are buying seed. The seed lot should also be free of weed seed. For commercial sales, there should also be no seed from other species. In practice, farmers may not mind mixtures of locally adapted varieties and species, especially for intercropping, and especially if these are maintained and co-adapted in the field over time. But even so, they will prefer to know what the mix is, rather than having unknown seed in the mix.

Sanitary quality refers to fungi, bacteria and viruses that can reduce seed performance. These diseases can also remain in the soil or in weedy relatives. Seed-transmitted diseases build up over time. There is evidence that infected seed has lower germination and increases abnormal seedlings and dead seeds (Bishaw et al., 2013).

Indeed, overall there is a lot of evidence that better quality seed can improve yields and sustainability of production. In commercial and farmer seed systems, the desired characteristics must be maintained in seed production, harvesting, handling and storage, otherwise the users will not get seed with the characteristics they want.

Quality control and quality assurance

There are many different and often overlapping definitions of quality control (QC) and quality assurance (QA). For the purposes of this paper, QC refers to the technical, practical activities that ensure the seed meets standards which are defined to a greater or lesser extent. These are internal processes and practices by the seed producer to ensure the seed meets

minimum standards. All producers across seed systems practise some form of internal QC (ISSD Africa, 2017:1). Quality controls are the practical methods through which the grower ensures seed quality across a range of measures. In farmer seed systems these include diverse and effective farmer practices which are not recognised in the formal system.

On the other hand, QA refers to the processes of monitoring, documenting and guaranteeing that quality controls have been performed properly in seed production/multiplication (see Quality Gurus, 2016). This is especially important for third party sales so that the buyer can trust the producer. Unless farmers aim to produce at commercial scale, QA is not essential. For farmer seed systems, we consider the potential of participatory guarantee systems (PGS)as an integrated QC/QA system.

Quality controls in farmer and intermediate seed systems

Most seed used by smallholder farmers on the African continent is reproduced by farmers themselves outside any formal processes of control. There are deep wells of farmer knowledge on seed QC as an integrated part of crop production, as well as seed maintenance and adaptation, even if this knowledge is uneven and diverse. Seed custodians who maintain, save, use and experiment with diverse crops and varieties are key individuals for agricultural biodiversity maintenance and conservation (Sthapit et al., 2013). Farmers' own QC practices do regularly generate seed of satisfactory or good quality (e.g. Kusena et al., 2017), and evidence indicates that farmers often prefer their own seed over improved formal sector varieties (see below).

'Intermediate systems' refer to seed systems where varieties are sourced from the formal sector and freely distributed to farmers for multiplication and further distribution, but without detailed QC support. Sharing quality seed for use and further distribution contributes to options and choices available to farmers. Good quality materials can be expected to propagate faster in conditions that suit them. As indicated above, some QDS programmes take this intermediate form. Intermediate approaches are also found where farmers participated in the development of varieties e.g. community-based seed production of participatory plant breeding (PPB) rice varieties in Nepal (Sthapit et al., 2012:55). There are cases of PPB farmers being involved in multiplication of the varieties they had developed in Honduras, Nicaragua, Cuba, Ethiopia, Bolivia, Malawi, Zambia, Zimbabwe, Madagascar, Mali, Burkina Faso, India, China, Indonesia and Philippines (see ACB, 2018). However, the literature tends to focus on the plant breeding activities and provides little or no detail on specific QC measures in multiplication, or the extent to which criteria in commercial seed laws and regulations were applied.

In conditions where varieties are shared with farmers for unregulated further use, QC is mostly the same as the informal QC in farmer seed systems. A challenge in non-commercial intermediate systems may be the lack of volume of quality foundation seed (which is bulked up from the registered breeder seed to generate enough seed for planting). In such cases the emphasis could be placed on managing decentralised QC in the bulking up process to retain quality, and on simple post-harvest QC. The advantages of the intermediate system include the introduction of new seeds and varieties for farmers to use and no restrictions on further use, and it allows for public sector support in multiplication and distribution because the varieties are formally recognised.

Given the marginalisation of farmer seed, there is very limited documentation of external support for quality control in farmer and (non-commercial) intermediate seed systems. NGOs and occasionally other researchers and technicians are known to work with farmers to provide technical support on biodiversity conservation and use and to maintain and improve seed quality, mostly based on good agronomic practice in the field and in storage. But well-documented examples are hard to come by. Recognising that "the lack of formal or commercial attention to informal systems

Table 2: QC and QA in intermediate and farmer seed production

System	Quality controls	Quality assurance
Intermediate (e.g. community seed production)	Registered varieties/materials In-field and harvesting selection criteria and practices Diverse handling, cleaning and storage practices Self-regulation Quality management protocols Possibly technical support	Voluntary Reputation and trust based Buyer seed inspection before purchase Possible use of participatory guarantee systems (PGS) Brand potential
Farmer	In-field and harvesting selection criteria and practices Diverse handling, cleaning and storage practices Self-regulation Quality management protocols	Voluntary Reputation and trust based Buyer seed inspection before purchase Possible use of participatory guarantee systems (PGS) Brand potential

has resulted in a low uptake and dispersal of quality farmer preferred crop varieties" in Ethiopia, ISSD Africa has started a specific programme to strengthen farmer seed systems, including on quality control (ISSD Ethiopia, 2017). However this work has only just started and results are yet to be documented and shared.

Seed production in farmer and non-commercial intermediate systems is often integrated with crop production and is reproduced and adapted through continuous use. In most cases, seed is produced in the same field and at the same time as crops, and crop agronomic practices will determine seed quality in the field. Farmers may identify plants for seed early and treat these differently. There might be seed-specific quality issues in the field and harvesting that do not necessarily apply to the crop harvest, e.g. concern about germination rates, moisture content, or maintenance of desired characteristics/genetic purity.

In some cases farmers may want to sell their seed at a commercial scale. Some intermediate systems are also established with the objective of multiplication and commercial sale of the varieties shared with farmers. Currently farmers may be limited to selling locally through seed fairs that sometimes cannot absorb all the seed for sale. In these cases there is likely to be some form of technical support on QC. Aside from formal sector contract farming, many development interventions to enhance seed security are based on an intermediate model oriented towards commercial sales, wherever possible. Indeed, there are hardly any case studies in evidence where external QC support is provided, where the objective is not to sell at a commercial scale. The obvious logic is that QC support is too costly if there are insignificant material returns to the seed producers/sellers. However, in the context where the majority of crops and seeds are produced and shared by farmers themselves and form the basis for food security in large parts of Africa as well as other parts of the world, some investment in improving quality can have significant positive impacts on food availability and security.

Sale at commercial scale outside the locality will generally require more stringent QC and a functioning QA system that can provide some confidence in the product, which means some form of integration into the formal system. This could take the form of QDS. Commercial markets for farmer seed are not well developed, especially since many of these varieties are tailored to very specific local conditions and find favour precisely for this local adaptation. However, some of these seeds may well find wider application, if given the opportunity.

Generally speaking, QC in farmer seed production in the field is very closely related to good crop agronomic practices. Not all farmers will practise these evenly, and

Farmer quality control in sorghum seed production in Kenya

A case study of farmer seed use and production practices of sorghum in Bomet District in Kenya gives a practical example of how farmers manage seed quality. It indicates that QC is practised unevenly, and that dissemination of simple, voluntary QC protocols can go a long way to improving seed quality without too much extra work or cost.

Farmers identified poor quality seed as a major threat to food security. The area is characterised by prolonged drought and erratic rainfall and sorghum is grown as a drought tolerant crop. However, there was a declining area planted to sorghum, partly because of declining yields over time. Farmers only got 2% of their sorghum seed from the formal sector, and mostly used their own saved seed or seed from neighbours, with a small percentage buying grain at the local market for use as seed.

> 92% of farmers in the study preferred their own seed over the improved varieties

Improved sorghum varieties were developed and disseminated to farmers by agricultural research institutes (ARIs) and extension services. However, 92% of farmers in the study preferred their own seed over the improved varieties. Farmers were not using the recommended improved varieties for the area, and certified seed was mostly not easily available. However, within the farmer system seed recycling is broken if there are poor yields or crop failure, and farmers may be compelled to use their seed as grain, and will then need to acquire seed from elsewhere for the next season.

In the field, two-thirds of farmers did not use fertiliser (it is unclear whether this refers to all fertiliser or specifically to synthetic fertiliser). Almost one-third of farmers planted with very high seed rates, which can cause competition between the plants as they grow. Farmers left thinning to intra-plant competition. However, this method can reduce nutrient availability to the eventual winners, resulting in lower yields than necessary. Broadcasting seed can also lead to lower germination, because some seed is not properly covered.

Birds are the main pest in the field and prefer improved varieties in this locality because they are sweeter than farmer seed. Farmers practised intercropping with maize to reduce bird damage. About 5% of farmers reported disease problems, but most farmers were not conversant with disease issues.

Of those who harvested seed separately, nearly one-fifth continuously selected for seed from the seedling stage. Seed was mostly harvested together with the grain and dried in the direct sun. After harvest, seed was threshed by beating the panicles with sticks or rubbing them on a hard surface. This can cause mechanical damage to seed, reducing the quality. Seed was stored separately from grains, with special precautions to avoid pest infestation. Storage was mostly at the fireplace or in kitchen ceilings, with smoke used for effective pest management.

Farmers said seed prices in the market are low, reducing the incentive to produce seed specifically for sale. Extension officers could play an important role in training farmers in on-farm seed production, popularisation of and access to locally adapted improved varieties, and promoting the benefits of sorghum consumption. Major constraints to on-farm sorghum seed production were identified as poor seed source; lack of socio-economic resources; poor crop husbandry; poor post-harvest handling of seed; damage by weeds, pests and diseases; and lack of marketing incentives.

Source: Ochieng et al., 2011

farmers could benefit from information about simple techniques that can be applied voluntarily to improve seed and crop quality.

Genetic quality is controlled in the field. This is about maintaining the desired seed characteristics in production, which farmers in their own systems may want to do. However, crossing is part of evolutionary crop development and adaptation to local conditions, and the idea of genetic purity must be adapted to accommodate farmer seed populations and materials.

There are longstanding and widespread practices - for example, of selecting the best and healthiest plants in the field for seed, selecting from the centre of the field and from different locations around the field, selecting from the centre of the cob for maize, and selecting for seed density rather than size - and there is deep knowledge about which seeds are resistant to pests and diseases, the signs for these, etc. At the same time, not all farmers know about these practices, or they use them unevenly.

Genetic quality of seed sourced locally is most often acceptable to farmers, as it is generally grown in nearby agroecological contexts that match their own needs (CIAT cited in Kansiime et al., 2018:13). There are many documented cases of farmers preferring their own seed over formal sector varieties, including locally favoured characteristics, and yield stability in stressed conditions over absolute yield. Preference is not identical to quality, but they are related, especially when there are choices on offer.

Smallholder farmers also have (uneven) knowledge about timing of harvesting, drying procedures, avoiding losses due to shattering or field infestation of storage insects, as well as care in harvesting and threshing to avoid damaging the seed (Almekinders and Louwaars, 1999:112).

On ***physiological quality***, germination tests are unlikely to be widely practiced, since the seed is generally known and there are not always alternatives to using the seed. Testing can give an indication of problems with the seed or management practices. Simple germination tests can be done (see Figure 5), although farmers may not practise these – probably either because they are not considered necessary or essential, or farmers do not know about techniques. Seed management practices can be considerably enhanced through simple explanations and demonstrations. For example, when Bioversity International assessed its work with community seed banks in South Africa in 2017, farmers mentioned this improved capacity as one of the benefits of their involvement.[5]

Farmers dry their seed either in the field or post-harvest. In Africa, maize seed is mostly left to dry in the field before harvesting and shelling. Drying in the sun, or under a light shed with air circulation, works well and is widely practised. Racks can be used to improve ventilation and allow for quicker drying. Humid climates pose more of a problem for drying.

An indication that farmers do consider seed moisture content is through the techniques they use to ensure seed is stored in dry and cool conditions. Traditional storage structures, such as those built to include mud walls or underground spaces, can keep temperatures relatively low. Farmers may use airtight containers to store well-dried seed. The seed must be dry, otherwise it will respirate in the container, opening possibilities for fungi and diseases. Glass jars or bottles may be sealed with wax, which also solves insect problems, because the oxygen runs out and any insects in the seed will die. Jars may be filled as much as possible to reduce the amount of air in the container. Humidity in the container is reduced by putting layers of fresh charcoal in the container and separated from the seed by newspaper, thus absorbing humidity. This is good for vegetable seed but is more difficult for bulky field crops like maize, which are stored in bags (Almekinders and Louwaars, 1999:113–115).

Analytical quality is also fairly easy to do at farm/household level. It essentially involves seed cleaning to remove non-seed materials (e.g. straw, stones) or weed seed, to select

5. Personal communications, Ronnie Vernooy, Bioversity International, 11 September 2018

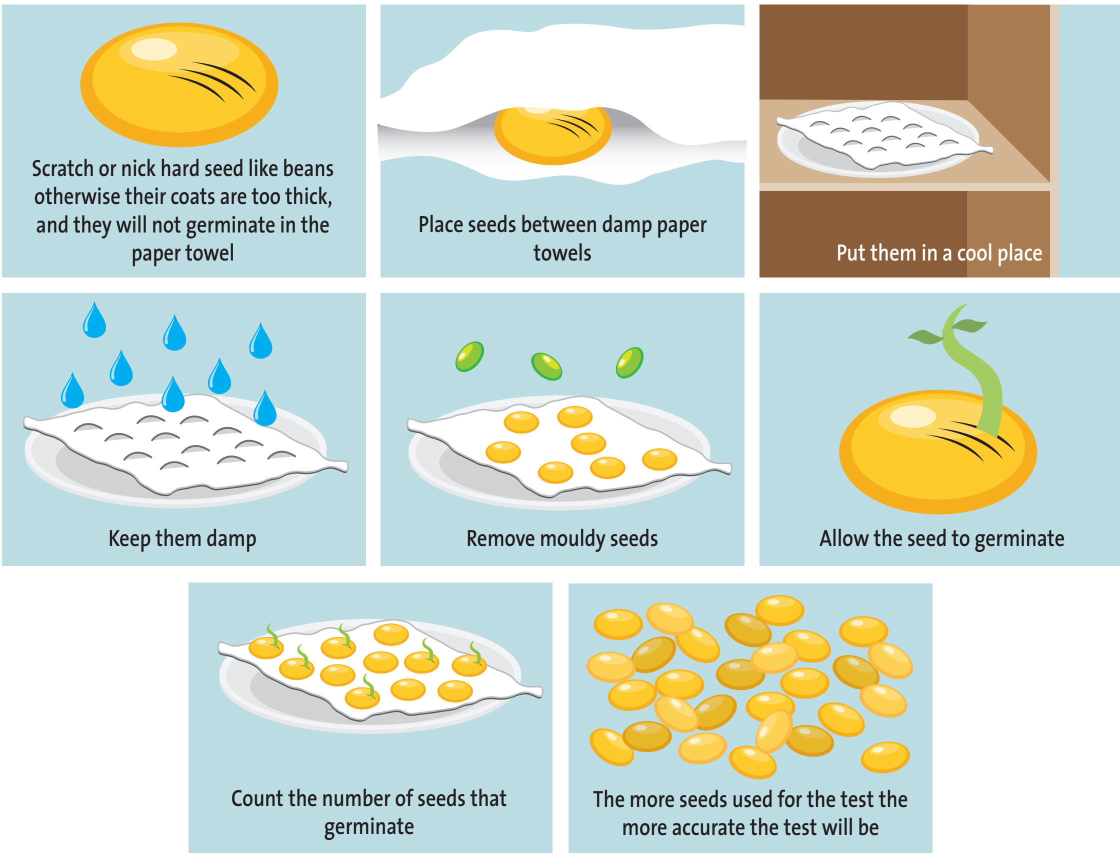

Figure 4: Simple germination test

the desired seeds and to remove shrivelled or small seeds. The methods are the same as for cleaning of crop harvests. Winnowing removes light particles, including seeds with low density; sieving can be used to select by shape and size, if required; and handpicking is done to remove diseased and discoloured seed. Some low-tech sorting machines are available for large quantities of seed, but, again, this is more for commercially oriented seed producers.

Sanitary quality may pose some challenges, but can be done at farm level for most purposes. Not all pathogens are visible, but they usually will manifest in seed and plant damage in the field. Selection of strong and healthy plants in the field for seed is the best route to good sanitary quality. In storage, hanging seed in smoke from the kitchen fire keeps it dry and reduces insect and disease damage. Bean seed may be mixed with a 25–50% ash ratio to reduce insect damage. The addition of lime to the ash can also help. Although ash is good in reducing insect damage, it also tends to discolour the seed, reducing its appeal when farmers intend to sell their seed through seed fairs.[6] For bean seed, a small amount of vegetable oil (5–10ml per 1kg seed) can be added to the seed to reduce insect presence. Rat traps are used to eliminate damage by rodents (Almekinders and Louwaars, 1999:113–115).

Case studies on intermediate and farmer seed production

This section provides a few selected case studies from Brazil and East Africa to show the different types of support that may be provided to smallholder farmers to produce quality seed from the populations and materials they maintain. The Brazilian case highlights a very impressive and successful model that responds to two key constraints facing farmers in producing their own seed for widespread dissemination: first, the lack of recognition of farmer seed, or restrictions on their sale if they are not registered; and second, the lack of organised markets for farmer seed, even if this seed may make a valuable contribution to food security

6. Personal communications, Bulisani Ncube, SDC, 10 August 2018

beyond the locality in which they have emerged. Based on sustained and long-term mobilisation and activities by civil society organisations (CSOs) and farmers, over time the Brazilian government recognised farmer varieties and integrated them into provincial and national food security programmes through public procurement and distribution of these seeds. The East African cases, in particular in Ethiopia and Kenya, indicate a range of tried and tested and sometimes innovative approaches, including seed farmer schools based on farmer field school (FFS) methodologies, demonstration sites and comparative variety trials, training, and seed banks. Key institutional factors for successful interventions are multi-stakeholder partnerships incorporating farmers, NGOs, researchers, and extension; and public sector buy-in and participation.

Support for production and dissemination of farmer varieties in Brazil[7]

Farmers in Brazil have organised community seed banks since the 1970s, especially in the semi-arid areas in the North East. However, as in sub-Saharan Africa, there was a lack of recognition of on-farm seed production in farmer seed systems. The Brazilian government adopted a seed bank policy from the 1990s, but the banks were filled with conventional seed (FAO, 2004).

Following drought in the early to mid-1990s, a coalition of CSOs in Paraíba in North East Brazil started working on decentralised, farmer-driven seed selection and distribution of farmer seed. The first step was identifying and enhancing the visibility of farmer seed practices. In 1996 the coalition started mapping farmer bean populations, led by farmers' unions and supported by Semi-Arid Network Paraíba (ASA-PB), the regional branch of the National Agroecology Network. They identified mechanisms farmers used to ensure availability and access of diverse seed. ASA-PB established a Seed Network, a knowledge exchange platform that eventually linked 230 seed banks in 61 municipalities. Following another drought in 1999, farmers protested the continued use of conventional varieties to fill the seed banks.

The Paraíba state government was persuaded to acquire local seeds for the seed banks. At that time, local seeds were not recognised as seed in national law. The state government circumvented this by buying the seed as grain and then transferring it to ASA-PB to distribute through seed bank mediators to farmers for sowing.

A state law was passed in 2002 to allow direct transfer from the government to farmers, and in 2003 the national government passed a seed law formally recognising 'local, traditional and Creole' varieties. Article 48 of the law expressly forbids restrictions on the inclusion of these seeds in publicly funded programmes for family farmers (Santilli, 2016:342). This was a result of popular pressure around agroecology. Initially exchange was restricted to that between farmers or within the same organisation, although these restrictions were lifted following the adoption of the National Policy for Agroecology and Organic Production (Planapo I) in 2012.

In 2003 FAO held a workshop in Brazil to identify major constraints facing on-farm seed production. The workshop process identified groups of limited resource farmers to be targeted and proposed solutions for increasing availability of good quality seed to smallholder farmers. Issues that were raised, in order of importance, were:

- Weak and low impact of public policies to promote quality seed production and access;
- Research and extension links;
- Use of participatory methods;
- Communication;
- Differentiated strategies for diverse contexts;
- Markets and on-farm value addition of seed;
- Literacy and professional capability;
- Excessively stringent commercial seed laws governing seed production and sale;
- Low availability; and
- Poor local adaptability of formal improved varieties (FAO, 2004:5).

7. Sources for this section: FAO, 2004; Peterson et al., 2016; Fernandes, 2017; Gabriel Fernandes from Aliança pela Agroecologia (APA), personal communications with Sasha Mentz-Lagrange 2017

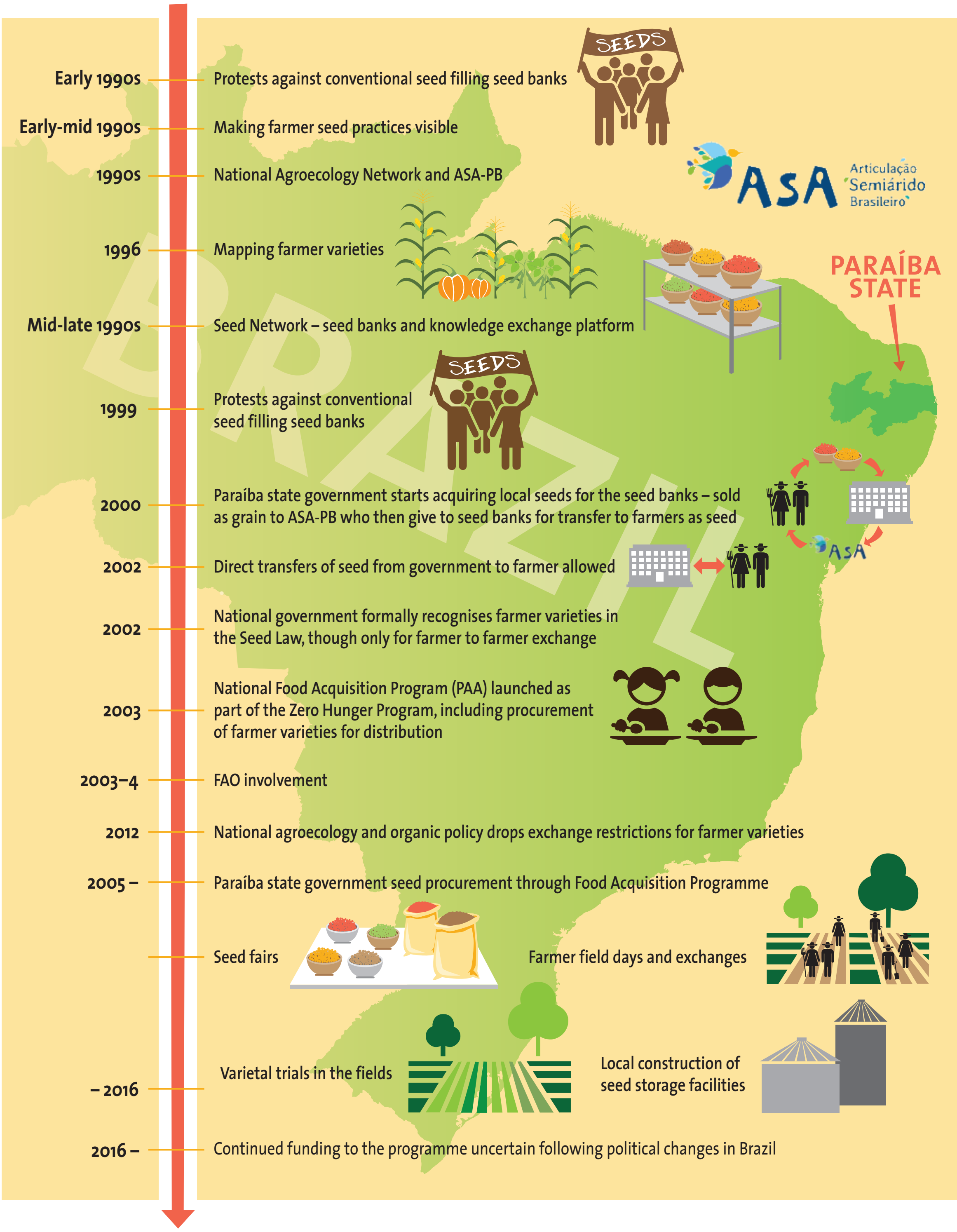

Figure 5: Brazilian model of support for farmer seed production

Opportunities in order of importance were:

- Readily available technologies and production resources for smallholder seed production;
- Policy trends towards integrated seed sectors;
- Interest in promoting the use of local seed;
- Positive experiences of participatory research and development (R&D) using local germplasm;
- A qualified skills base in teaching, research and extension; and
- A national seed system that recognised on farm seed production (FAO, 2004:5–6).

Overall recommendations from the workshop were that:

- There should be national programmes with financial resources for on-farm seed production by resource-limited farmers and other rural communities;
- Programmes should coordinate and promote multi-institutional cooperative projects that recover and conserve local seed and those developed through participatory methodologies; provide technical assistance and training to local seed multipliers; and training on marketing;
- Funds should be made available for regional research and technology exchange; and
- Use should be made of the existing public and private sector skills base in teaching, research and extension (FAO, 2004:7–10).

The national government's Food Acquisition Programme, launched in 2003, included the purchase and dissemination of farmer seed. Assistance was provided to farmers to produce and distribute their seed, which was directly purchased from and distributed to farmers (Petersen et al., 2016). This created a big incentive for local producers. Policy recognised farmer groups, such as family farmers, agrarian reform settlements and indigenous communities and populations, and recognised seed production activities in these communities. The Ministry of Agrarian Development supported seed fairs to promote multiplication of local seed (FAO, 2004:14–15).

Simple techniques were practised, including agroecological training and farmer field days and exchanges. Seed custodians were identified, and programmes supported conservation, multiplication and distribution of diverse seed, with local exchange and seed fairs for distribution and sale. Technical assistance came from local government and extension (FAO, 2004).

However, the idea that conventional seeds produce better could not be dislodged from the minds of policymakers. All seed still had to go through formal QC processes, although there was recognition that genetic uniformity is intrinsically not appropriate for farmer seed, which is by its nature genetically diverse (Fernandes, 2017). ASA-PB began partnering with research institutes, including Embrapa, the public sector agricultural research agency, which helped with acceptance and legitimacy. Projects compared the performance of farmer seed and conventional (formally improved) varieties using participatory approaches. Participatory research and experimentation included seed health and quality and the effects of intercropping, based on three years of experiments.

The seed that performed best in an area usually originated in that area

According to Petersen et al. (2016), farmer seed outperformed conventional varieties in all areas except on highly fertile soil with good rainfall, which are not conditions most smallholders work in. The seed that performed best in an area usually originated in that area. Locally constructed seed storage facilities worked well. Embrapa has committed to making germplasm from gene banks available for farmer production. However, lack of enabling policy or a supportive legal environment remain major constraints for seed banks and farmer selection, production and distribution. Social mobilisation and collective action are very important to push governments (Petersen et al., 2016).

In 2015, a national programme called Semi-Arid Seeds (Sementes do Semiárido) was launched, reaching nearly 128,000 farmers. It included construction or revamping of 640 community seed banks, including equipment

Seed banks

Smallholder farmers usually select seed from their harvest for replanting, but there is no specific multiplication of this seed. However, farmers may want to increase the volume of seed they have produced after harvest. Farmer-managed seed banks can function as a connecting point between PPB or farmer varieties, and bulking up of the seed for own use and distribution. Seed banks are a collection of local seeds and associated information and knowledge. They can be of varying degrees of complexity and formality, ranging from individual and household seed banks to national and regional community seed bank networks. Seed that enters can be multiplied out in plots connected to the seed bank. QC is present in the form of storage, handling and bulking/ multiplication methods, as well as in-field management and selection. Seed banks, and the production and in-field selection of seed bank varieties, provide continuity to local evolutionary processes.

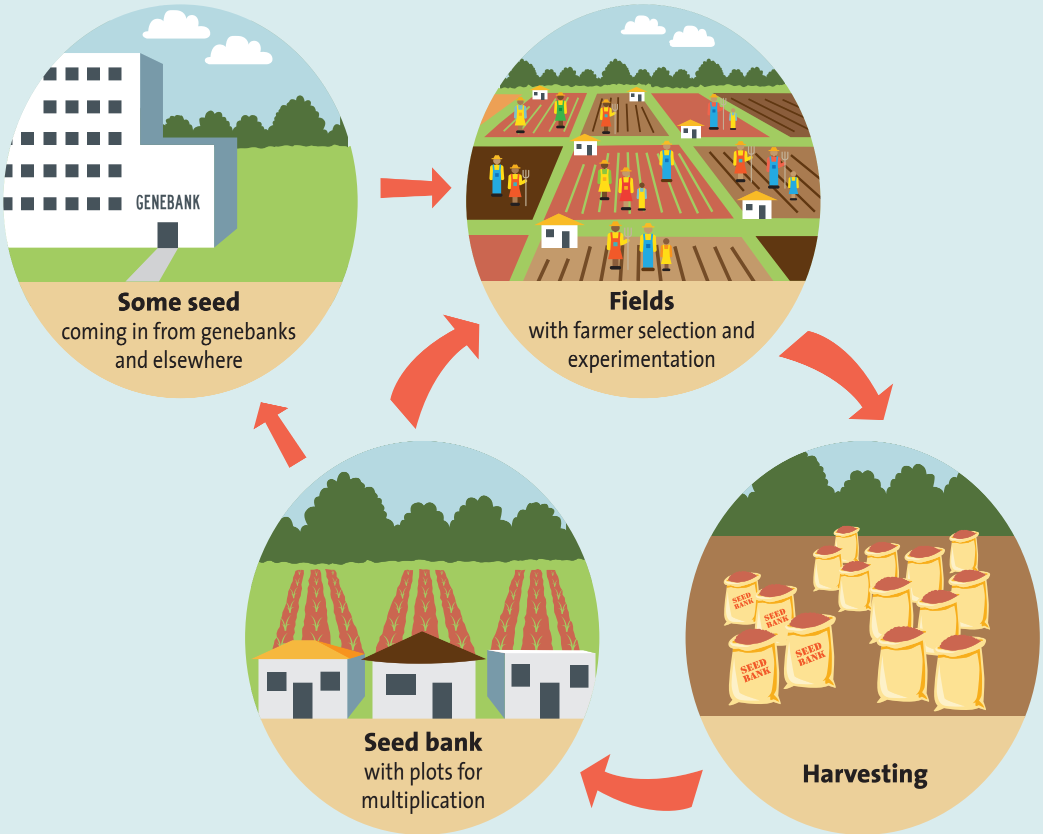

Figure 6: Seed banks

Seed banks are usually locally maintained and managed, with rules and procedures, including QC, formulated to meet producer and user interests. Roles and responsibilities are explicitly defined by participants and are context specific. External support may be provided in the form of conceptual and practical training on handling and storage; good practices by development partners and users of seed from the bank to maintain quality and assure seed return; and training on seed selection. Initial external support (based on local commitment and contribution) may be needed, especially for group organisation, purchase of storing equipment/materials, and preparation of storage structure (Sthapit et al., 2012:41–43). Practical work is being done, and there is a high level of interest in seed banks in Africa. Case studies in this report indicate the important role of seed banks in farmer seed production strategies from Brazil to Ethiopia. Other examples from Nepal (Sthapit et al., 2012) and Latin America (FAO, 2004) reinforce this role.

and capacity building. However, since the deterioration and rightward shift of political conditions in Brazil in 2016, funding has dried up and the programmes are battling for survival.

Seed farmer schools in Ethiopia

The Quality Seed Promotion Project for Smallholder Farmers (QSPP) in Ethiopia was a joint project by the Ministry of Agriculture and Japanese International Development Agency (JICA) which ran from 2010–2014. The project included seed farmer schools (SFS) in three regions: Oromia, Amhara and Southern Nations, Nationalities, and People's Region (SNNP). The schools were based on FFS methodology but specifically focused on seed production, and specifically wheat and teff. The project provided access to quality seed, support for practical local seed production and QC training for farmers through improved agricultural machineries and cultivation techniques, and production for local markets. Participating farmers produced on 0.1ha seed production plots.

FFS methodology consists of three overlapping areas: agroecosystem analysis (AESA), group dynamics to enhance team building, and special topics for technical skills. Facilitators of special topics can be farmers, extension workers, researchers or others. QSPP used 'train the trainer' methods, with 32 weeks of learning sessions of 3–4 hours each. Content included agronomic practices, land preparation, AESA, fertiliser, weeding, markets, pest and disease control, harvesting, threshing and cleaning, submitting samples to laboratories, and storage, with the use of farmer exchanges and field visits. The overall results were increased yields, with farmers indicating improved seed quality. Most farmers said they would like their seed quality to be tested, with 93% willing to pay for the service. The study did not explore the reasons for this.

The overall results were increased yields, with farmers indicating improved seed quality

Challenges included that a manual for SFS was not produced; high turnover rate of facilitators; lack of transportation or incentives for facilitators; facilitators not reporting; 'master trainers' were from outside Ethiopia; farmers did not record their activities; and few farmer groups conducted any activities after graduation from the training, with most farmers returning to integrated production and no longer setting aside land specifically for seed production once the project ended. Farmers called for further technical support, ongoing supervision and guaranteed markets. Land shortage, labour intensity, and inaccessibility of required quality seed and skills were the main reasons farmers gave for not engaging in seed production on separate plots.

Farmer-based seed multiplication programme in Ethiopia[9]

Another Ethiopian project was the farmer-based seed multiplication (FSBM) programme arising from the national Growth and Transformation Plan (GTP) 2010–2015, based on supporting local farmer organisations to produce seed for local exchange and sale on markets. FBSM was defined as any form of seed production and supply conducted with or by farmers, but mostly outside commercial markets. A goal of the programme was to increase agricultural productivity through improving access to and use of quality seeds from both formal and farmer seed systems, with improved production of locally demanded varieties. The programme sought to meet diversified demand for seed based on differing agroecological and socioeconomic contexts and different sets of actor-networks. A wide diversity of crops was produced, with marketing support where useful. Seed demonstration sites were established and maintained for alternative crops and varieties.

Federal and regional organisations and donor agencies in Ethiopia were involved in FBSM implementation, with a diversity of actors,

8. Source for this section: Yagi et al., 2014
9. Source for this section: Alemu, 2011

including Ethio Organic Seed Action (EOSA), Catholic Relief Services (CRS), Institute of Biodiversity and Conservation (IBC), Relief Society of Tigray (REST), research and learning institutions, public seed enterprises, and the Royal Netherlands Embassy (with a commercial agenda through its Local Seed Business Project). There were diverse agendas amongst the partners, including:

- Landrace conservation and use;
- Access to and adoption of new varieties;
- Increased production of certified seed of popular varieties; and
- Promotion of local commercial seed enterprises and integrated seed sector.

The programme supported the formation of community seed banks (CSBs) across Ethiopia, making available planting material (relatively large seed samples) and genetic materials where varieties were lost (relatively small seed samples). Farmers could sell commercially, but this was not required. CSBs have potential for mobilising collective action on local conservation and use of plant genetic resources.

The programme sites were in drought prone areas, with 16 CSBs in central, eastern and southern Tigray supported by REST, a local NGO. This was initially a response to seed shortages and linked with Catholic Church community-based maize seed multiplication, which fed into CSBs and local markets.

Research–extension–farmer partnerships conducted research-based FBSM for the introduction of new varieties. ARIs facilitated researcher-led demonstrations in farmer fields and other popularisation of new varieties to connect with farmers and provided agronomic and crop protection advice. Popularisation included farmer training, extension support in demonstration areas, and communications. A 'farmer research group' approach was adopted, where end users are included in discussions about preferred varieties and influence variety development and seed production. The research institutes used participatory plant breeding (PPB) and participatory variety selection (PVS) to develop and promote adoption of different varieties. A key objective was to increase the germplasm pool available to farmers to experiment and adapt at will. It opened opportunities for seed marketing for those who wanted to. The release of popular PPB teff varieties stimulated demand and FBSM. Ultimately a PPB teff variety was formally released and became the most popular variety nationwide. Selected varieties were disseminated through farmer-to-farmer exchange and integrated into farmer seed systems. There was no quality certification for FBSM activities outside commercial production, except the measures taken by farmers themselves based on their own knowledge of quality. However, there were policy constraints in that this unregistered seed continued to be defined as 'illegal'.

Ultimately a PPB teff variety was formally released and became the most popular variety nationwide

Moving to the more commercial side of the programme, national and regional public seed enterprises (PSEs) faced increasing seed demand but had limited land for seed production themselves. As a result, they contracted farmers to multiply formally released varieties. They established farmer clusters for QC purposes and simplified supervision and extension logistics. Farmers retained as much seed as they needed for their own purposes, and then sold the rest to the PSE for commercial sale. FBSM was important in the overall Ethiopian seed system and a major portion of seed for teff, barley, field peas, lentils, chickpeas and a big portion of bread wheat seed was produced through the programme. Across fifteen major crop types, FBSM was used on 44 out of 63 certified varieties produced by the Ethiopian Seed Enterprise (ESE). South Seed Enterprise (SSE) contracted farmers for hybrid maize seed multiplication, and FBSM for all its open pollinated varieties (OPVs) (wheat, teff, barley, haricot beans, chickpeas, faba beans) with two to four varieties per crop.

Challenges for the PSE FBSM model included: lack of farmer organisation; need for intensive supervision and challenges for QC and supervision with many dispersed and distant plots; production variability exacerbated by rainfall and soil variations;

inability of farmers to adhere to a commercial delivery schedule, which disrupted commercial operations such as logistics, planning and order fulfilment; resource limits in the PSEs to acquire the necessary skills in procurement, processing, packing and transport, and infrastructure/facilities; and quality rejection and low recovery rates of quality seed (the amount that is collected from farmers). The latter could have been a result of farmers holding seed back because they could use it or sell it for a better price than ESE was offering. While this threatened ESE profit (and potentially the model) it did appear to benefit farmers. In the words of the author of the study, "low seed recovery for ESE means increased access to seed for farmers" (Alemu, 2011:9).

The third part of the programme was providing support to establish business-oriented seed enterprises, including cooperatives and local seed businesses sponsored by the Dutch government. We did not look at the details of this, since it followed the standard commercial model of multiplying improved varieties for sale. But it did show that some projects incorporate production both for commercial sale and for less controlled dissemination into farmer systems.

Promotion of sustainable sweet potato production and post-harvest management through farmer field schools in East Africa[10]

Sweet potato is an important food crop in East and Central Africa and is grown mainly by women. In urban areas, it is historically considered to reflect low income status of consumers, but health consciousness is leading to greater acceptance. Production area has expanded but yields have declined. The main reasons are lack of planting materials of appropriate cultivars, weevils in drier areas and viruses in wetter areas, low soil fertility, lack of markets, and short shelf life of roots after harvest.

Shortage of planting material frequently follows a prolonged dry season. There is little opportunity to select cleaner, young vines for planting, resulting in pest and disease build up. Mostly late maturing varieties are available and they only mature when the soil has dried, creating opportunities for weevil infestation. Farmers mostly do piecemeal harvesting (as and when needed) but if there is weevil infestation, they will harvest the whole crop to limit damage. This results in a short-term glut on the market. Regional breeding programmes have developed high yielding varieties adapted to low input conditions, with testing for resistance against major pests and diseases and formal multiplication schemes with smallholder farmers.

The UK Department for International Development (DFID)'s Crop Protection Programme ran a project from 2002 to 2005 to promote farmer production of sweet potato seed. It included laboratory, on-station and on-farm research with farmer experiential learning. Implementing organisations were the Natural Resources Institute in the UK with the International Potato Centre (CIP) and the Ugandan National Research Organisation (NARO). The project was implemented in North Eastern Uganda and Western Kenya with a link to a FAO integrated pest production and management (IPPM) programme in North West Tanzania.

Participatory development of location-specific protocols, manuals and materials for sweet potato IPPM were developed and field tested in FFS for use by extension workers and FFS facilitators. The manual included a background on FFS and facilitation skills; technical information from plant material selection and land preparation through to post-harvest processing, storage, alternative products, marketing, and information on experimentation; a sweet potato FFS learning curriculum; learning activities and monitoring and evaluation (M&E). The manual was adapted from one developed in Asia, with the main manual in English for use beyond East Africa. Shorter field leaflets targeted at farmers were produced and translated. Farmers were trained on IPPM through a 'train the trainers' course with extension workers and FFS graduates. Initially this was for two days, but farmers and facilitators requested a longer training period to cover the topics properly, so it was extended to a week. Farmers and extension

10. Source for this section: Stathers, 2005

Photo credit: Anne Wangalachi/CIMMYT

workers also requested training on tissue culture, even though they were not going to use it practically.

'Master trainers' were active extension officers/field agronomists fully employed by the Department of Agriculture, which brought technical and organisational knowledge and experience. District-level agricultural departments in discussion with project leaders selected trainers, and there were locally based project assistants. Some problems were experienced with accountability and poor commitment of trainers, in particular the extension workers who tended to default to top-down training methods. This indicated that good facilitation skills are very critical (Stathers and Kapinga, 2006).

Sweet potato IPPM FFS modules were institutionalised into large-scale FFS programmes adopted by national extension and CSOs. Results were improved household nutrition, increased production, more farmer experimentation, sales of value added products, and preservation of clean planting material through the dry season.

According to the researchers, varieties should be generated together with good production methods and nutrition information. Extensive farmer training is required to adapt techniques to local contexts and FFS is a good model. Participatory M&E in the field is a key part of QC. Indicators can be developed through such processes, including what form of data to collect (vine length, insects, diseased leaves, plant parts, yield); collection, analysis, visualisation and group discussion of the data; individual record keeping; and participation in planning and evaluation meetings. FFS participants chose to experiment on varieties, planting techniques, vine length, manure application rates, pest and disease symptoms and management, soil fertility assessment, processing and product development, rapid vine multiplication and conservation, record keeping and pit storage of roots. The idea was raised of establishing nurseries for commercialisation of planting materials.

The project faced some challenges: FFS are long and demanding, and at times conflicted with other activities; training was complex and over-technical; there was

uneven commitment and participation in training sessions – some said there should be more training, some said there should be less; farmers could not always see the real difference in their production; there were challenges with illiteracy in relation to record keeping and monitoring; it relied on farmer voluntarism; and there were difficulties in translating group work at the FFS into individual practice at home.

Support for production of farmer varieties in Kenya[11]

A study of on-farm seed production of maize in Western Kenya to improve yield and quality of farm-saved seed found that 80% of maize seed came from the farmer seed system. Farmers indicated certified seed requires a lot of inputs for good performance and this is too costly. Although some quality aspects may be neglected, the yield of local seed is still acceptable, compared with poorly performing improved varieties produced in stress conditions, and farmers said stability over many seasons is more important than the highest yield. Farmer seed has high genetic variation, which diffuses risk. Most local seed is tolerant of stresses and will produce a yield even in unfavourable conditions. Despite this, breeders, researchers and policy makers neglect farmer seed. Farmers indicated late harvesting, striga infestation and low soil fertility as the main constraints they face.

A project was started to borrow methods from the formal sector to increase the quality of farm-saved seed. A participatory approach was adopted for adaptation and dissemination. The project involved on-farm trials at seven sites, and on-station trials at Siaya Farmers' Training Centre, using five farmer varieties/populations and a striga tolerant population. Different local varieties were used in different locations. Comparisons were made between seed plots that received nitrogen and phosphorus applications, later followed by top dressing; and unfertilised plots. Harvesting was done at both physiological maturity and harvesting maturity. Plot design was controlled (e.g. spacing, breaks) and data collected on plant height, striga effect, striga population, lodging severity and yield.

Generally, farmers' agronomic practices were found to be poor and this can compromise yield and seed quality. Pest and disease control were not widely practised. A minority of farmers rogued (removed off-types or diseased plants in the field), maintained soil fertility following nutrient extraction after harvest, or had information about recommended plant spacing. Seed produced under conditions of low soil fertility may express poor germination and vigour and nutrient stress at plant development and seed-fill stages reduce seed quality. Of farm-saved seeds, 31% had fungal infections identified during germination testing, while 10% of samples had germination rates of less than 10%. Insect build-up during production can extend to storage. Striga also took nutrients from the plants.

> Local seed without fertiliser had the best cost-benefit ratio

Farmers use plant height as an indicator of maize seed quality. Plant height increased significantly with fertiliser application. Fertilised plants had higher seed weight, but excess nitrogen also caused a significant increase in lodging. Maximum seed vigour and viability was found at harvest maturity rather than physiological maturity, against prevailing wisdom. Local seed without fertiliser had the best cost-benefit ratio indicating that the cost of (purchased) fertiliser mostly outweighs benefits. Farmers will not adopt new varieties unless these can show benefit without a lot of extra resource requirements. In principle, the experiment shows that results are better on fertilised than unfertilised land. This could also be organic fertiliser.

Overall these cases indicate many different experiences of QC in farmer seed production. It appears that the best ways to improve seed quality, whether for own use or for sale, are to make diverse quality source materials available for unfettered farmer use and adaptation in their own contexts;

11. Source for this section: Wambagu et al., 2012

Figure 7: Farmer-based seed quality controls

develop and share simple QC protocols; and decentralised technical support where possible, including facilitated farmer-to-farmer exchanges. Self-pollinated crops are relatively easy to multiply, with some training. There is little risk of admixture, off-types can be easily removed, isolation distances are minimal, and expensive seed processing plants and certification units are not needed. Cross-pollinated crops, e.g. maize, are more difficult to manage. Off-types are more difficult to detect, and large isolation distances (300+ metres) are required (Monyo et al., 2004:8). Extension services can play a crucial role in training farmers on seed production and QC. This should cover appropriate varieties of crops most farmers grow, with simplicity as a key feature of QC (Monyo et al., 2004:9).

Quality assurance in farmer seed systems

Quality assurance, the documentary verification processes that run alongside QC practices, is not needed where farmers

are saving seed for their own use. Even where farmers exchange or sell seed locally, QA may not be essential, since buyers will mostly know the seller and the exchange relationship will be based on trust and personal reputation. Buyers may be able to inspect the seed's performance in the field, if they live nearby. Generally, this will be adequate for crops with little yield benefit from quality seed, crops that are not prone to seed-borne diseases, and crops that are traded locally, direct from the farm gate (ISSD Africa, 2017:5).

QA will become relevant in farmer systems where farmers want to sell commercial quantities of their own seed to buyers who do not know them personally. Third party certification is not always suitable for small operators and local market channels because of cost and complexity of norms (Bouagnimbeck, 2014:10). However, a lot of farmer seed is produced and traded without external QA, so it is legitimate to question what value external QA adds. It is a service to producers and buyers, so it must be of value to them. When is it a necessity and when is it a luxury that is not essential? Availability and supplier reputation are the most important bases for seed acquisition decisions. Farmers may be willing to pay a small premium for external QA, where this is accurate and confers a recognised advantage. However, the premium must not outweigh the benefits of using the seed, farmers must be convinced of the QA, and there must be a difference in yield potential over their own or other seed. This is likely to rule out those who are producing only for home consumption, and therefore QA will mostly focus on market-oriented production (ISSD Africa, 2017:2).

Group-based QA systems may be adopted where producers are working together, with internal quality checks based on an agreed protocol. However, these may be difficult to sustain if producer numbers increase too much. They are also vulnerable to internal politics and power dynamics, and sanctions may be difficult to enforce if inspectors are association members (ISSD Africa, 2017:6).

Participatory guarantee systems for seed quality assurance

PGS is a practical, farmer-based QA system that aims to provide a believable guarantee to buyers that quality controls have been performed. Although PGS has been used primarily in organic agriculture, the model can easily be adapted for farmer seed production, drawing on lessons learned from more than 20 years of experience in PGS in the organic sector. A review by the International Federation of Organic Agricultural Movements (IFOAM) revealed that five out of eight selected case studies were doing collective seed management and conservation alongside organic PGS work (Bouagnimbeck, 2014:38), including trial farms, community seed banks and seed sharing (Bouagnimbeck, 2014:41). This makes sense, because limited access to organic and indigenous seed is often an obstacle to the expansion of organic production (Bouagnimbeck, 2014:42). Tanzania, Uganda, South Africa, Zimbabwe and Burundi lead the field in developing PGS in Africa (Bouagnimbeck, 2014:16).

PGS was initiated in smallholder organic production at a workshop hosted by IFOAM and Movimiento Agroecológico Latinoamericano (MAELA) in Brazil in 2004. It is a decentralised process, where marginal smallholder farmers can participate in certification processes for local markets. It offers an alternative to third party certification options, which are usually too expensive, controlled by agribusiness or inappropriate for local contexts (Braganca n.d.:5). PGS is based on locally focused QA systems. Producers are certified through active stakeholder participation built on a foundation of trust, social networks and knowledge exchange (Braganca n.d.:6). Farmers, consumers, traders/buyers, and potentially others, such as extension, local agriculture departments, NGOs, academics/scientists, etc. all participate in shaping the vision, designing the system and structures, testing and implementing the system, peer review and decision-making. Trust is rooted in conscience and commitment (Braganca n.d.:12).

Key features of PGS (Braganca n.d.:14):

- Norms are conceived by stakeholders and recorded;
- Local groups manage the process;
- Principles and values seek to enhance livelihoods and promote organic (farmer seed) production;

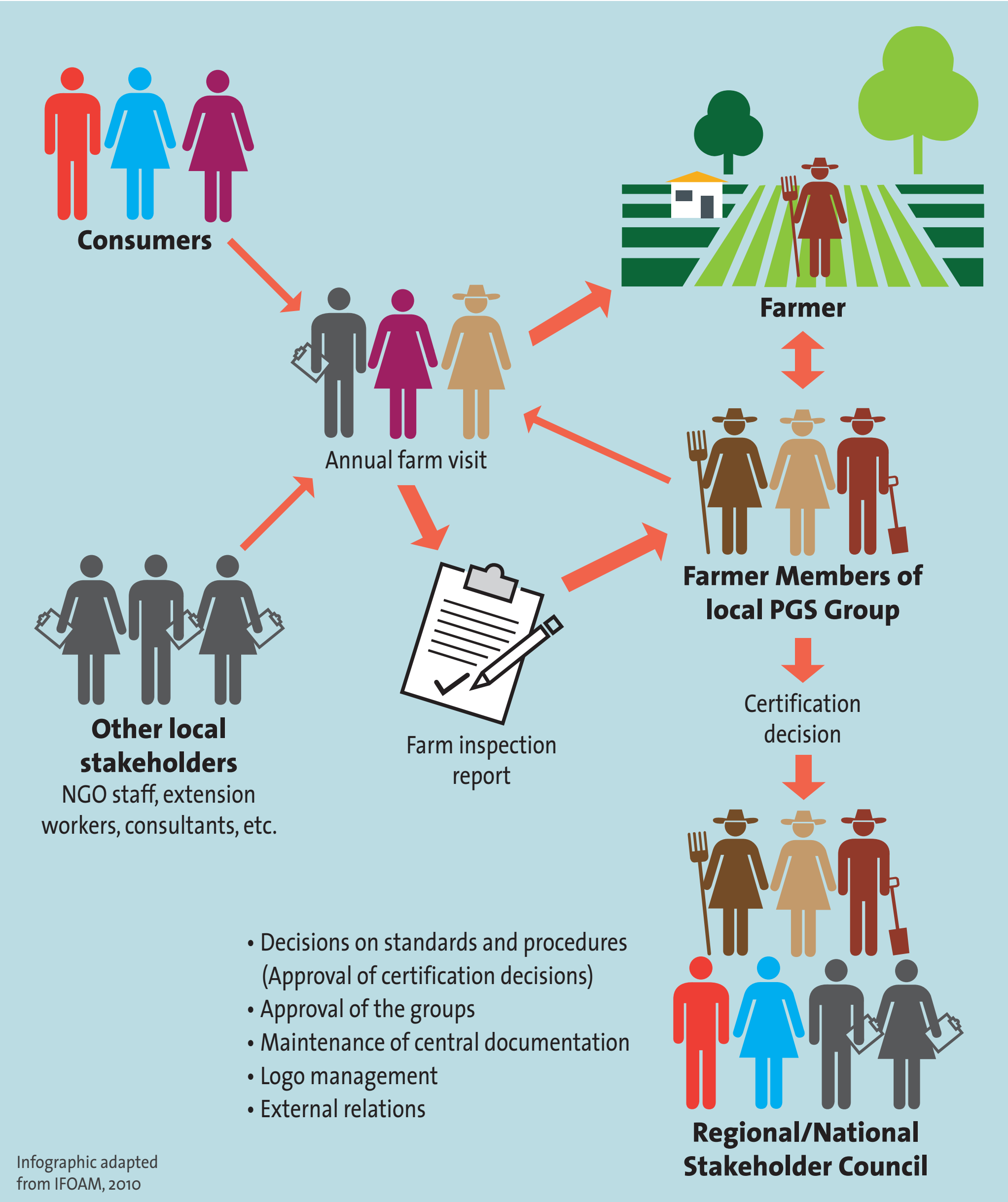

Figure 8: Participatory Guarantee System (PGS)

- Management systems and procedures are documented;
- Mechanisms are designed to verify farmers' compliance;
- Mechanisms for supporting farmers are constructed;
- Farmers take a pledge, and make a commitment to comply;
- Labels are standardised; and
- Consequences are clear and pre-defined.

The PGS system developed by IFOAM and partners starts with local producer groups of five or more farmers who assist one another to become and remain compliant with basic standards (Braganca n.d.:20). An individual farmer joins a local group, does training on basic standards, takes a pledge, and attends field days. A local inspection group – which may also include other stakeholders such as consumers – conducts annual on-farm peer inspections and physical checks on the property of group members. The local group then collates the pledge, with inspection and attendance of each farmer, decides who will be certified, and acts on fraud/non-compliance.

According to the Association of Sustainable Agriculture Practitioners of Palimbang (ASAPP), which is part of a PGS in the Philippines, inspections of production units are the most important part of the process. QC officers and inspectors from different participating farmer associations do the inspection. There is no self-inspection. At

least two inspections are conducted, at the vegetative stage and at harvest. The system is based on voluntary participation (no paid officials). The main costs are training and farm inspections. The scheme is self-funded through revenues generated from group activities (Bouagnimbeck, 2014:24–25).

Developed PGS systems have regional and national networks of local groups to strengthen the system, reinforce trust, develop the PGS, carry out advocacy, and provide a platform for sharing experiences and tools. Where regional networks have been created, regional councils are formed with representatives from local groups. The local groups report to the regional council on annual production and prepare and submit summary worksheets and inspection reports. The regional council checks worksheets for completeness, may decide on certification based on the report plus other documentation, follows up on non-compliance, passes the documentation to the national coordinating committee (NCC), gets identity numbers from the NCC and issues these to local groups, and issues certificates to farmers. The certificate permits the farmer to use the PGS brand or label to sell their product. An appeal committee is available for farmer appeal on decisions. The NCC maintains the identity document system, registers local groups, conducts random testing, maintains traceability, may decide on standards, and represents PGS to external actors such as government (Braganca n.d.:25; Bouagnimbeck, 2014:12–13 and 24–25).

> inspections of production units are the most important part of the process

Mechanisms to verify compliance include evaluation sheets, peer reviews, procedure manuals and regular meetings. The latter also stimulate participation, organisation and learning (Bouagnimbeck, 2014:12). Documentation includes basic standards, a farmers' pledge, PGS guidelines, reporting formats for local groups, communications within the system, and training and information exchange (Braganca n.d.:17). Access to information and training is a key means of support. This can take the form of visits by field advisors, newsletters and field visits (Bouagnimbeck, 2014:12).

PGS ideally operates within a set of parallel social processes that can have a positive impact on PGS initiatives. These

The Green Foundation's seed participatory guarantee system in India

The Green Foundation in Bangalore, India works on conservation and use of indigenous rice, millet and vegetable seed. The Foundation started in 1994 and adopted PGS to guarantee production standards. They adopted the same process as organic PGS and linked into the national PGS system, based on voluntary work by farmers (Bouagnimbeck, 2014:28–30). The Organic Farming Association of India (OFAI) set the standards.

Indigenous seeds are sourced from community seed banks. Farmers multiply the seed, which is then returned to the seed bank and distributed from there; it is also sold through Janadhanya, a local farmers' association. Farmers pay for seed production or otherwise free seed is provided on condition of return of twice the amount at season's end. Profits are used to expand the seed bank and support farmer initiatives.[12] The Green Foundation seeks out rare indigenous species in use around India and brings them back for in situ conservation and use at their own research farm and to share with farmers in their fields and in kitchen gardens. They also maintain demonstration plots. The seed banks are almost entirely run by women (Bouagnimbeck, 2014:42). If certification is denied, the Foundation provides further guidance to farmers to be able to comply and is thus not punitive but supportive.[13] The Foundation works with a wide range of partners, including the International Crop Research Institute for the Semi-Arid Tropics (ICRISAT).

12. http://www.greenfoundation.in/seed-multiplication/
13. http://www.greenfoundation.in/certification/

Figure 9: Benefits and weaknesses of PGS for smallholder seed production

include collective marketing; sharing experiences, techniques and traditional knowledge; collective seed management and conservation; small-scale saving schemes; socialised pricing; and collective work and mobilisation of a committed, informed and supportive consumer base. PGS may stimulate these and, in turn, if some of them are present, they can be a factor in the success of PGS (Bouagnimbeck, 2014:vii).

Strengths of PGS include stronger producer–consumer relations, smallholder access to QA systems, local development based on local cultures, ownership and responsibility, low direct costs, and less bureaucracy (Braganca n.d.:23). Evidence shows positive economic, social and ecological impacts of PGS, improved social bonds, farmer empowerment, lower production costs, better market access and regular sales, enhanced

food security, and better management of natural resources (Bouagnimbeck, 2014:vii). PGS provides a good platform for sharing information, techniques and traditional knowledge amongst farmers. Field inspections and meetings are used not only to monitor but also to share information and knowledge (Bouagnimbeck, 2014:39). Important factors for success include access to markets, participation options, ownership, conflict resolution and gender roles (Bouagnimbeck, 2014:vii).

Weaknesses of PGS include: a high degree of dedication needed from stakeholders; capacity building involves long-term processes; lack of formal recognition; complex social organisation; voluntary work; and high indirect costs (Braganca n.d.:23). Challenges include: involving consumers, which is easier said than done; gaining public and government recognition for the QA system; getting financial and technical support from authorities; overcoming long distances and difficulties of access between different members of the group, and from farm to market; increasing the limited understanding of PGS, even amongst participants; improving poor documentation and record-keeping, which can be a result of illiteracy/low levels of education and lack of a culture of record keeping; and dependence on voluntary work to make the system function (Bouagnimbeck, 2014).

Key issues arising

QC is very important to ensure farmers have access to good seed. Formal sector QC is designed for the specific purposes of standardised, uniform seed for commercial sale. Unfortunately, this system has been imposed on all seed sales. However, farmer-based QC practices can also be effective in ensuring farmers have access to quality seed for planting, and purely formalistic restrictions on their ability to do so are damaging and threaten food security.

It is evident that most crops and seeds are still being produced and circulated by farmers and remain critical for diverse food production and agricultural biodiversity in many parts of the world. In many cases, farmers express a preference for their own seed, for reasons of yield stability, seed availability, preferred traits and adaptation to local conditions. Despite their ubiquity and value in smallholder production systems, farmer seeds are not recognised in the formal system, and may even be criminalised regarding sales.

Limitations imposed by commercial seed laws and formal sector rules, the skewing of R&D towards a narrow range of lucrative crops under the control of multinational corporations, and contract farming mean that farmers' activities around agricultural biodiversity conservation and use are uneven, and under serious pressure from climatic, demographic and production system changes. Likewise, farmer-based QC is also unevenly practised; not all farmers practise good selection, crop management, rogueing in the field, pest and disease control, soil fertility, harvesting and storage and other methods that can ensure good quality seed. Sometimes this knowledge has been lost or farmers are not aware of the full range of possible practices that may be deployed.

There are many practical challenges to supporting farmer-based QC, including (among others) costs and the general lack of resources; skills and knowledge shortfalls and costs of training; dependence on voluntarism; weak incentives for farmers to participate in seed production, because of limited financial returns and high time and labour commitments required; illiteracy and poor documentation, which makes systematic work more difficult; the requirement for good facilitation skills; and lack of farmer organisation and weak organisational structures.

Registration of farmer seed may make sense for sales at commercial scale, since it is there to protect the buyer. However, for non-commercial production, there are questions about the objectives or benefits for farmers. One possible benefit of registration is recognition of farmer seed, although registration is not necessarily required for recognition. For example, Brazil has written recognition of farmer seed into the law itself, and outlaws discrimination against these seeds in public programmes. Another potential reason for registration is defensive,

Photo credit: Georgina Smith / CIAT

to prevent others from claiming IP rights over seeds farmers have developed and are already using. This may be necessary in the context of plant variety protection (PVP) laws that allow for private and exclusive ownership of plant varieties but doesn't go beyond this context.

PGS offers a potential model for farmer-based support to improve quality, where buyers may be prepared to spend extra for quality. It is innovative in terms of working in networks of farmer associations, with peer-to-peer QC based on group reputation, and creates an incentive to maintain standards (the right to sell PGS seed as a trusted brand). However, PGS is organisation-intensive and requires active voluntary participation, and a weakness so far has been the difficulty of getting users/consumers involved. It requires active involvement of farmers who may not have time, or for whom the benefits may not be enough to justify spending the required time and resources on it. Experiences to date suggest that, although there may be improvements in access to and quality of seed and farmers do find training helpful, the improvements are seldom enough to justify ongoing activity by farmers once the funded projects are over. Market access is potentially a key issue, hence the importance of building markets, so there is demand for diverse quality farmer seed and crops. Again, involvement of consumers/buyers in prioritising, implementation and decision-making may be needed but remains a challenge to realise in practice.

Elements for success of interventions to support farmer-based QC:

- Almost all long-term successful activities are rooted in persistent and ongoing social mobilisation, coupled with practical farmer-based work. Externally imposed projects will go nowhere if seed production and training is not demand driven and if there is no demand for the crops and seed varieties/populations.
- Participatory multi-stakeholder approaches should incorporate farmers, farmer associations, researchers/agronomists, NGOs, public sector extension, local government, consumer associations and others, with the use of existing skills base for training, research and extension.
- The Brazilian case was a nationally driven initiative, with farmers driving the demand and organising themselves. Brazil highlights the important roles of farmer organisation and moblisiation, including protest action, the state, changes in the

seed laws, and partnerships between farmers and state/researchers without donor intermediaries.
- There are many tried and tested methods and practices, including training (and the production of manuals and curricula); farmer field schools and farmer-based research groups, starting with identified seed custodians; demonstration plots and in-field comparative trials; seed fairs; seed banks, with local seed banks as a possible point of quality controlled multiplication of farmer seed and some possibly formal sector varieties (e.g. OPVs from the public sector that are shared with the seed bank); gene banks sharing germplasm with farmers for further development, multiplication and sharing; support for democratic organisation; decentralised farmer-to-farmer sharing and learning, facilitated by farmer associations, NGOs, and/or government extension; and active involvement of buyers and consumers in participatory QA systems.

Policy implications

Differentiated strategies are required for commercial and non-commercial production. Currently non-commercial production is neglected or even criminalised if farmers try to sell their own seed. This is unjust and ecologically dangerous. The aim should not be to impose QC unnecessarily. QC must benefit farmers as seed producers and users. For non-commercial production, any QC support should be tailored to respond to specific quality concerns arising from users, rather than imposing a blanket QC model on all farmers everywhere. QA does not appear to be essential for farmer seed for own use or non-commercial sale or exchange. It should be voluntary.

Both formal (specifically for OPVs) and farmer seed systems can contribute to increased choice, availability and access to good quality seed for smallholder farmers. Both should be recognised and efforts to regulate the formal/commercial system should not unnecessarily or unjustly impede farmer-based systems and practices.

There is consensus that sales at a commercial scale means commercial standards should apply. Even so, there could be some flexibility to consider specific characteristics of farmer seed when defining standards, even for commercial sale.

Existing ***seed laws*** should be ***restricted to the commercial sector***, based on a ***threshold*** to define commercial scale. There are various possible means of defining the threshold, but enterprise turnover (e.g. seed business or total enterprise) potentially offers the simplest and most inclusive means. Using farm size or volume of production may create challenges because these will vary greatly by ecological zone and crop type, necessitating many different thresholds. Enterprise turnover could easily be linked to national definitions of small and medium enterprises.

Complete exemptions can be granted for farmer seed and/or categories of farmers ***below the threshold***. On categories, Brazil identifies smallholders, agrarian reform farmers, and indigenous communities and populations as eligible for automatic exemption. An important inclusion in some seed laws, such as in Brazil and India, is the farming community, because this opens the space for exemptions for local exchange between farmers. Where there are complete exemptions, there may also be voluntary registration of farmer seed based on farmers' own needs and potential benefits of registration in the specific context.

Exemptions should go hand in hand with explicit ***recognition of farmer seed populations/varieties***, otherwise these seeds may not get any public sector support for their maintenance, enhancement and reproduction over time. Again, Brazilian and Indian seed laws offer good examples of explicit recognition of this sort to enable support to be channelled to farmer seed activities and varieties/populations.

Commercial PVP laws restrict farmer access to quality seed, and usually mean increased costs to farmers. Although this paper does not deal with PVP as such, exemptions should include exchange and even sale of protected varieties below the threshold, as permitted in some countries.

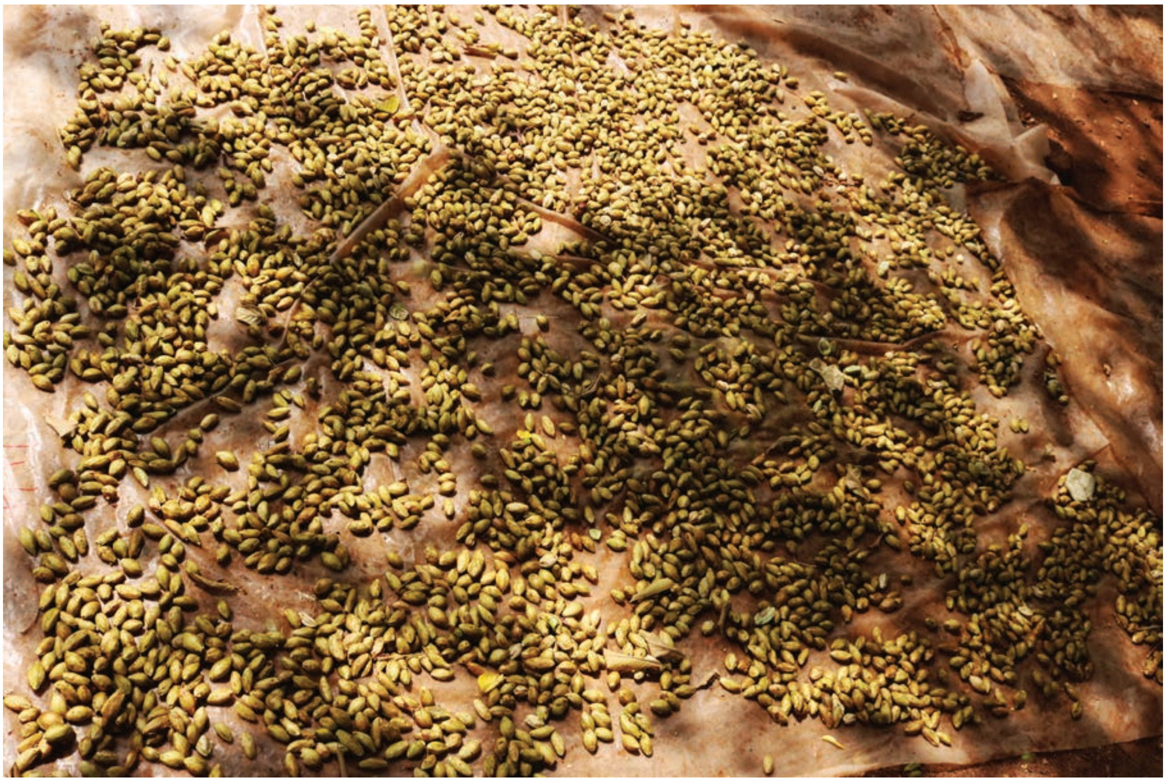

Photo credit: Andrew Wu, World Resources Institute

Flexibilities/partial exemptions in commercial laws could be granted if complete exemptions are not granted. This could apply to non-commercial, and/or farmer seed, and/or for specific producer categories. Some examples of flexibilities or partial exemptions that do exist in some seed laws and policies are:

- Exemption from DUS, or replacement with distinct and identifiable (DI). There may still be specific markers defining a variety, to indicate the essential characteristics at various points in time. Farmers could potentially register populations and then adapted versions with similar characteristics in future years would remain on the register even as they change over time, as long as they can be identified;
- Exemption from VCU tests, on the basis that value has largely been proven by the years of cultivation in farmers' fields;
- Separate farmer seed lists with relaxed qualification criteria. Criteria for registration could be based on qualitative data from farmers, including major traits, the history of use in the farming community, and/or that the seeds were developed, adapted and produced by smallholder farmers;
- Exemptions or relaxed standards for premises and enterprise registration for seed production and selling to open space for farmers and their seed to enter into production, without fear of sanction;
- Subsidy or exemption from fees for categories of producers; and
- Possible relaxation of standards, such as for germination or percentage of off-types if these can be justified.

Expansion of non-commercial intermediate seed systems can be of great benefit in increasing smallholder access to quality seed and adapted seed varieties and populations. In essence, this means freely sharing formal public sector, PPB and open source varieties for unregulated further use. There are no quality issues, since the breeder and foundation seed has already passed through strenuous checks and the seed is safe for release for unregulated use in recommended agroecological areas. They are usually already based on genetic materials farmers have been using and improvements are often tailored for local contexts. This is a good model for crops with high seed rates and low multiplication rates (Monyo et al., 2004:8). One challenge may be the lack of enough volume of the foundation seed, which will

require seed producers who can bulk up the seed for wider distribution while retaining its quality. These measures can infuse the system with fresh material and offer a base for farmers to experiment and adapt as they wish. Agricultural research institutes, universities, NGOs and extension can work with farmers to maintain, improve, use and distribute diverse materials. This can play a key role in overcoming the challenge of limited availability of quality source seed at the root of quality seed production.

Separate, distinct ***policies for farmer seed systems*** are needed, to recognise farmer varieties, seed practices and categories of farmers; and to lay the basis for support and programming. There are strong links here to operationalising the ITPGRFA and farmers' rights, and a farmer seed policy can connect closely with national plant genetic resources plans.

The content of such a policy could include:

- Forms of collective ownership over genetic resources that allow for continued free sharing and exchange of these resources at farmers' disposal;
- Participatory plant breeding and participatory variety selection;
- Recognition of diverse farmer-based QC practices and simple, cheap means of sharing (what can farmers do that does not involve a lot of training and external intervention?);
- Documentation and sharing of key farmer-based QC practices and techniques; and
- Facilitating markets for farmer seed, in particular, public procurement of diverse crops for food and nutrition security programmes; and stimulating local markets through infrastructure support and promotion/advertising of diverse crops and farmer seed, e.g. nutrition information, processing methods, and recipes and preparation advice.

Although QC and QA should be voluntary for smallholder farmers for non-commercial production, these producers can benefit from ***voluntary, clear, pragmatic crop-specific and decentralised QC management protocols*** (see Appendix 1 for some considerations) offering norms, steps in crop management and administration through the growing season, and monitoring. Farmers working with researchers and extension can develop QC knowledge and techniques (Gildemacher et al., 2016; ISSD Africa, 2017), with training and information shared in farmers' preferred formats. Women traditionally manage seed in farmer systems and could play a central role in developing and sharing knowledge and techniques. Demonstration plots with lead farmers and experiential learning techniques, farmer field schools/farmer seed schools are key methods (CABI, 2014:20).

Key factors in quality seed production are:

- Quality genetic inputs;
- Good agronomic practices in the field;
- Selection practices; and
- Harvesting, handling and storage practices.

Exemptions, flexibilities and farmer seed policies and programmes will be developed and operationalised at national level. However, regional harmonisation of seed laws may pose obstacles to advancing recognition and support for farmer seed and farmer seed systems at national level.

> *Few regional agreements include or support any of the exemptions/special treatment that we see in some national laws, and since those agreements are one of the main driving forces in the next generation of national seed law development, they represent lost opportunities to promote seed system integration. As a result, any such accommodations in national law will be purely voluntary efforts at national levels, without the benefit of encouragement from the actors supporting regionalization. (ISSD Africa, 2017a:12)*

This requires a***djustments to regional seed protocols and agreements*** to ensure the full recognition and support for farmer seed systems and appropriate QC measures.

Glossary

'Commercial seed system' refers to specialised seed production at commercial volumes. The threshold between 'commercial' and 'non-commercial' should ideally be defined in national regulations. 'Non-commercial' in turn, overlaps with farmer seed systems but is not identical, since commercial scale is only a measure of quantifiable production.

'Farmer seed' od 'farmer seed populations' refers to seed that has been developed over time by farmers in production in interaction with the natural environment. In this paper, farmer seed is used as a general term incorporating local seed, landraces, indigenous/traditional seed, conservation seed, and so on. All of these have in common that they are produced and adapted with farmer intervention in processes of production.

'Farmer seed systems' refers to all farmer biodiversity conservation, adaptation and use, including planting, experimentation and adaptation, selection, storage and reproduction of seed.

'Formal seed system' refers to the technical aspects of seed breeding and production through private companies, research institutes and universities, for example.

'Plant breeding' refers to formal sector breeding processes. Adjacent terms are 'crop improvement' and the wider 'biodiversity conservation and use', to which we add 'adaptation'.

'Quality control' refers to the technical activities that ensure the seed meets standards, which may be defined to a greater or lesser extent. These are internal processes and practices by the seed producer to ensure the seed meets minimum standards.

'Quality assurance' refers to the processes of monitoring and documenting that quality controls have been performed properly.

'Rogueing' refers to the removal of off-types or diseased plants in the field.

'Seed' refers to all genetic materials that are used to plant crops, including vegetatively reproduced crops. The term is used interchangeably with 'genetic materials'.

Abbreviations

ABS	Access and benefit sharing
AESA	Agroecosystem analysis
ARI	Agricultural research institute
ASA-PB	Semi-Arid Network Paraíba
CENESTA	Centre for Sustainable Development and Environment
CSB	Community seed bank
CSO	Civil society organisation
DUS	Distinct, uniform and stable
ESE	Ethiopian Seed Enterprise
FAO	Food and Agriculture Organisation of the United Nations
FBSM	Farmer-based seed multiplication programme
FFS	Farmer field school
FPIC	Free, prior, informed consent
IFOAM	International Federation of Organic Agricultural Movements
IP	Intellectual property
IPPM	Integrated pest production and management
ITPGRFA	International Treaty on Plant Genetic Resources for Food and Agriculture
M&E	Monitoring and evaluation
NCC	National coordinating committee
NGO	Non-government organisation
OPV	Open-pollinated variety
PGS	Participatory guarantee system
PPB	Participatory plant breeding
PSE	Public seed enterprise
PVP	Plant variety protection
QA	Quality assurance
QC	Quality control
QDS	Quality declared seed
QSPP	Quality Seed Promotion Project for Smallholder Farmers, Ethiopia
R&D	Research and development
REST	Relief Society of Tigray
SDC	Swiss Agency for Development Cooperation
SFS	Seed farmer schools
VCU	Value for cultivation and use

Appendix 1: Key QC techniques for farmer seed systems

Genetic quality

- Practise good agronomic methods, including soil fertility (increasing soil organic matter), water, spacing, intercropping, crop rotation, etc. to produce healthy plants.
- Start selecting seed plant candidates already from seedling stage.
- Select strong, healthy plants for seed in the field before crop harvest – disease and pest-free, vigorous, favoured characteristics, productive.
- Select seed from the centre of the field, and from different locations around the field.
- For maize, select cobs with closed tops, select seed from the centre of the cob.
- Select plump, well-filled seeds.

Physiological quality

- Germination: Test by putting 25–100 seeds between damp paper towels until the end of normal germination period and see how many germinated. If the numbers are low, it means there are problems with the seed or management process.
- Moisture: Dry seed under a light shed with air circulation; store in a cool, dry place; use airtight containers for storage.
- Protect stored seed from rodents.

Analytical quality

- Exercise care in harvesting and threshing to avoid damaging seed.
- Remove inert matter by winnowing or hand sorting.
- Remove weed seed and seed of other species you do not want with this seed by hand sorting.
- Remove small, discoloured, damaged or diseased seeds.

Sanitary quality

- Use in-field selection of strong, disease and pest-free plants for seed.
- Use smoke, ash and other methods to protect seed from storage pests and diseases.

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