

Hermetic Seed Storage Technology

Principles, use, and economics – a practitioner's guide

Hermetic storage is the process by which oxygen is depleted and replaced by carbon dioxide, thus controlling grain storage pests without insecticide. A variety of storage types – from clay pots, to plastic bottles, to specially designed plastic bags, to metal silos – can achieve a hermetic seal with varying levels of effectiveness and cost per unit of seed/grain stored. Drawing from the experience with hermetic storage in different projects, this brief presents lessons learned, discusses the cost trade-offs and the role that storage can play in other aspects of on farm seed management such as seed selection, harvest and conditioning. Some brief recommendations are also provided, aimed at practitioners who are designing, monitoring, and evaluating hermetic storage activities.

Introduction: the centrality of farmer saved seed and seed management

Seed is the foundation for the production of cereals and grain legumes that underpins farm family food security and income across Africa. Throughout the African continent, farmers produce an estimated 80–100% of the seed of both local and improved varieties. The recognition of the centrality of farmer managed seed indicates that research and development practitioners need to support this important system and seed source (see Figure 1). Farmers typically produce seed and grain in the same field, although there can be wide variation between crops and cropping system. Methods for seed selection also vary, as seed might be selected in the field or after harvest, or from stored grain only at the time of planting.

Farmers often struggle to prevent losses in stored seed, which may impede their ability to maintain quality supplies for planting. Rather than taking a risk, farmers may decide not to store seed but rather to purchase from the grain/seed market prior to the next sowing season. On-farm hermetic storage prevents insect damage and helps farmers better manage their own seed, supporting increased food security in the region.

There are compelling reasons why farmers might not produce and save their own seed for different crops. These include (1) difficulty in storing seed, (2) reduced production due to disaster, (3) knowing that good quality seed can be sourced off farm, and (4) dissatisfaction with the variety. While some of these reasons are opportunistic and may benefit farmers, many times pest infestation and rotting of stored seed are easily avoidable with simple technologies. It is this constraint which this brief will focus on addressing.

The crop focus of on-farm seed storage is generally on lower value food security crops that are relatively easy for farmers to manage. These include grain legumes and cereals, especially rice and wheat that are self-pollinated but also pearl millet and sorghum. Integrated seed sector development is aimed at integrating formal and farmer seed systems, and tends to have less focus on commercial and more focus on developmental seed systems (see Figure 2).

Farmers who are reliant on their own saved seed typically struggle to access seed of new varieties that come from the formal seed sector (either the public or the commercial sector). Farmers who have problems storing seed between the harvest and the next planting season sometimes decide to not take the risk. Rather than storing their own seed, these farmers purchase seed off farm – usually from the grain market but increasingly from the commercial seed sector.

The direct effect of hermetic storage is that farmers are able to store more seed and maintain excellent quality. The indirect effects that are part of a seed management theory of change are that as farmers become more aware of seed as distinct from grain, and begin accessing new varieties, and begin producing seed separate from grain, they manage seed carefully and avoid accidental mixing of varieties.

Take-home message

- ▶ The vast majority of seed utilized by small-scale farmers in developing countries, especially cereals and grain legumes, is produced and stored on-farm. Major problems such as mold and insect damage can be avoided and higher seed quality retained through embracing more effective storage strategies such as hermetic storage technologies.

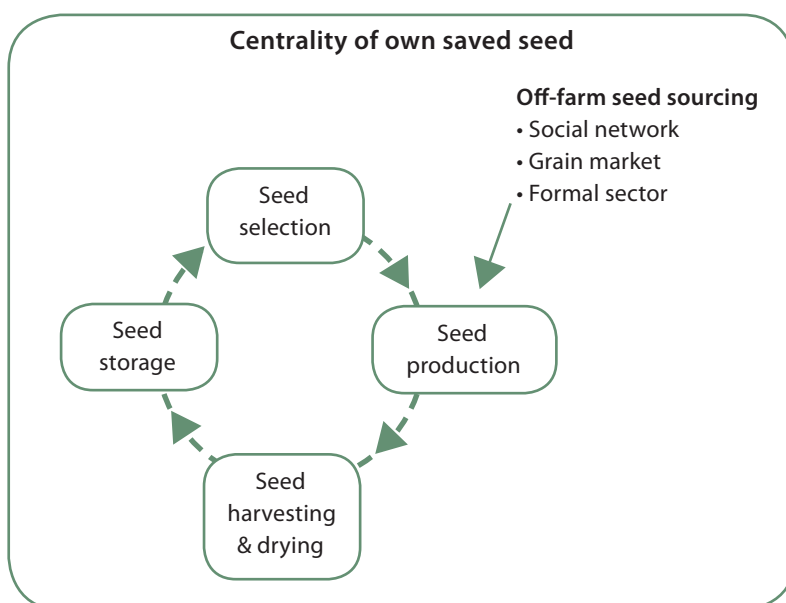


Figure 1: Key components for farmer managed seed

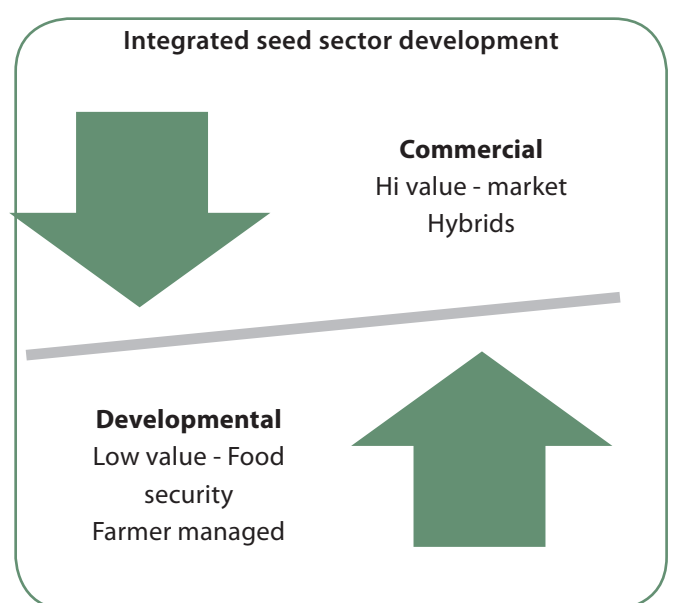


Figure 2: Adapted from Louwaars and de Boef (2012)

Principles of hermetic seed storage

Hermetic storage is a technology that enables farmers to store their own seed for long periods without loss due to insects and without using any insecticides. The technology consists of enclosing seed in air-tight containers that prevent or minimize gas exchange. Insect aerobic respiration depletes O₂ and increases CO₂. Insect feeding ceases, and therefore insects begin dying (Murdock et al., 2012). There is no need for insecticides. Additionally, hermetic storage can impede the growth of fungi as these organisms also need oxygen to proliferate (Quezada et al., 2006). This technique can maintain seed quality for up to one year of storage.

Humidity and managing moisture can be a challenge. Hermetic storage both locks in and locks out moisture. Adequate drying of seed prior to storage is not a problem in the dry Sahelian climate, but can be a major problem in the humid tropics, especially during the first season harvest. In the humid tropics, simple moisture meters can be used to quantify seed moisture prior to storage (though small producers use more risky “bite” tests for dryness). Seed must be dry prior to storage, approximately 12–14% moisture. Drying seed is a real challenge in the humid tropics. High moisture contents in hermetically stored grain such as maize can lead to loss in germination and viability and thus dryness must be ensured (Weinberg et al., 2007). Hermetic storage can also keep seed dry in the event of flooding.

The simplicity and profitability of hermetic storage are resulting in significant adoption, but it cannot be assumed that farmers are already employing this technology everywhere and correctly. In seed storage assessments in Burkina Faso and Kenya, a significant number of farmers using hermetic storage also used insecticides as an added, albeit unnecessary, insurance. It is therefore important to emphasize both necessary (drying, proper sealing, avoiding bag puncture risk) and unnecessary practices (insecticide supplements) in hermetic storage education.

Take-home message

- ▶ Hermetic storage works by allowing the insects to naturally respire and exhaust oxygen levels in an airtight environment to the point where they cannot survive. Insecticide or fumigation is not necessary. However, many grains must first be properly dried to about 12–14% moisture to avoid loss in germination and viability.

Hermetic seed storage technologies – an illustration

Three types of hermetic seed storage containers are promoted for use by smallholder farmers. These include locally available containers, Purdue Improved Crop Storage (PICS) triple-layer sacks (Baributsa et al. 2012), and GrainPro Super Bags (Villers, Navarro, and de Bruin, 2008). PICS sacks are composed of two high-density polyethylene plastic liners and a printed woven polypropylene bag for reinforcement. GrainPro Super Bags are sold as a single polyethylene liner with a proprietary formula, for which farmers must generally purchase the necessary woven sack for reinforcement. Unlike local woven bags which simply “organize” grain without providing protection against insects, hermetic bags provide full protection against insects without the need for any additional treatment.

The most common locally available containers include simple water bottles and recycled vegetable oil containers. The 5 and 20 liter vegetable oil containers are quite popular in villages throughout Africa and are typically used to store water and local beverages. Figure 3 provides an illustration of a variety of vegetable oil containers that are available locally in many parts of Africa which can provide a hermetic seal.

PICS (Baributsa et al. 2013) and GrainPro sacks come in 50 and 100 kg sizes (See Figures 4 and 5). This is typically more seed than a farm household requires for storage, though the flexible material allows for compression to store smaller quantities such as 20–25 kg. However, the bags can be used to store seed from more than one household or more than one crop – with the different seed lots in separate, non-hermetic sacks, placed inside the larger PICS or GrainPro sacks. These sacks can also be used for effective long-term grain storage.

Take-home message

- ▶ Hermetic containers for seed storage include locally available plastic bottles and 20L jerry cans, as well as multi-layer Purdue Improved Crop Storage (PICS) triple-layer sacks and GrainPro SuperBags.



Figure 3: Locally available hermetic storage containers



Figure 4: PICS sack



Figure 5: GrainPro sack



Figure 5: GrainPro sack

Hermetic seed storage supply chains

Local containers rely on existing, informal supply chains. These containers can be recycled easily and are inexpensive, but are often needed for purposes besides seed storage and must be replaced every 2–4 years. Old, dilapidated local containers can also present problems with sealing and must be verified before use.

PICS sacks have established small but maturing supply chains in many cowpea regions of West and Central Africa, with about 1,000 participating vendors. However, there is need to develop and expand this chain to reach greater numbers of farmers. In East and Southern Africa, there have been limited efforts to disseminate the technology among farmers to stimulate demand and hence the need for supply chain development. As an initial step in developing supply chains, Purdue has identified plastic manufacturers in several countries. PICS bags are currently being produced in Kenya, Rwanda, and Uganda, while production is also being tested with manufacturers in Tanzania and Malawi. Supply chains will be driven by agro-dealers and others.

GrainPro bags, due to economies of scale in production and quality control, are manufactured solely in the Philippines for global distribution. The bags are slightly more expensive than PICS sacks and so the supply chain has focused on major distributors as well as pursuing large sales contracts with governments and non-government organizations. While the cost of many hermetic storage technologies is low and the returns for farmers look promising, a major challenge is providing incentives of sufficient economic returns for suppliers in order to maintain the supply chain.

Where supply chains are non-existent for hermetic bags, like the situation outlined in the Burundi case study, plastic bottles and jerry cans are the only locally available hermetic seed storage options. While awareness campaigns are critical to create demand, new products must become available in the market. Therefore, as supply chains are strengthened, Burundian farmers who prefer using hermetic sacks will have more options.

Take-home message

- ▶ Locally available plastic bottles and jerry cans are almost universally available hermetic storage options, while the strength of PICS and GrainPro supply chains is currently limited and varies regionally.

Economics of hermetic seed storage

Storage begins with the assumption that farmers have selected high quality seeds after harvest – poor quality seed from the start will not improve with storage. After seed quality is assured, evaluating the economic advantages of hermetic seed storage requires asking several key questions. The following inquiries may be a starting point:

- ? What are the losses during storage with current practices?
 - Do farmers understand these losses?
- ? How much seed must farmers purchase at planting time (at elevated prices) because they did not take the risk of storing or had to replace seed lost to pests and rotting?
- ? Do farmers still plant seed damaged in storage? If so, what negative effect does this have on resulting germination and plant vigor?
- ? Do farmers increase seeding rates due to damage in storage? If so, what is the wasted cost of this extra seed over the entire planting area?
- ? What is the cost of alternative hermetic options compared to current practices?

Benefits of hermetic storage which provide economic advantages to farmers include:

- Reduced physical losses,
- Ability to sell seed (and grain) over a longer period and achieve a better price,
- Improved quality of seed leading to lower seeding rates,
- Improved plant vigor, and – ultimately – improved yields.

Examples of economically advantageous hermetic storage range from cowpea seed in Burkina Faso, bean seed in Burundi, maize seed in Timor Leste, to pigeon pea seed in India. The CRS experience from Burkina Faso, outlined in the included case study, demonstrates that large PICS sacks have a significantly lower cost per kilogram stored than locally available containers. It should be noted that the average life span of the PICS and GrainPro bags is 2–3 years, which means that they must be replaced more frequently than most local containers. Hence, supply chain management becomes paramount to increase the availability of cost effective options for small producers. Figure 6 illustrates the storage cost per kg using different containers.

Concerning hermetic pigeon pea seed storage, Vales et al. (2013) compared storage in PICS and gunny sacks. There is a reported 1% bruchid infestation with PICS compared to 17% infestation in gunny sacks. They also report 88% germination in PICS compared to 69% in gunny sacks and increased seedling vigor in PICS, measured as increased length of the seedling radicle and plumule.

The best recorded economic investment in hermetic storage is with pulses – especially cowpea and pigeon-pea. The reason is that these crops are often devastated by bruchids and it is common for a farmer to lose 50% or more of these stored pulses when using traditional (non-hermetic/no use of pesticides) methods (Baributsa et al., 2010). Additionally, high value crops like cowpea can more than double in price, economically outperforming lower value maize storage. While maize also shows good results, they are not nearly as strong as the pulses (Jones et al., 2011). The economic benefits of hermetic grain storage have not yet been thoroughly investigated for rice, wheat, pearl millet and sorghum seed in the semi-arid tropics, as well as for groundnuts when stored in the shell.

Figure 4: Unit (kg) cost of hermetic storage in Burkina Faso

Type	Number	Weight	Price (US\$)	Price/kg (US\$)
PICS	179	100	1.70	0.02
VegOil	22	25	3.00	0.12
VegOil	446	20	2.50	0.13
VegOil	2,115	5	1.24	0.25
Mineral Water	1,484	1.5	0.25	0.17

Take-home message

- ▶ The economic benefits of improved seed storage are largely derived from reduced physical losses, reduced seeding rates, increased germination and vigor, and ultimately higher yields. These benefits must be compared for each crop with the costs of new vs. traditional storage practices.

Recommendations for designing hermetic storage activities

Important steps for a successful seed storage extension or intervention effort should include:

- Implementing a seed system assessment with a focus on seed storage,
- Describing current on-farm seed storage of food security crops and diagnose problems,
- Selecting priority crop for seed storage,
- Selecting hermetic storage technology,
- Identifying leverage points for investment.

The seed system storage assessment should be used to describe and diagnose current farmer storage practices. It should evaluate seed quality and problems with insect damage and fungal damage due to high seed moisture. It should establish a baseline of the quantity of seed in crops stored, the percent loss in storage, and include the frequency of hermetic storage and use of insecticides (alone or in combination with hermetic storage).

With an extensive understanding of the function and benefits of hermetic storage and how it may improve the lives of local producers, your effort may be well on its way.

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