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Developing Community Seed Banking Practices through Low-Cost Appropriate Technology Use

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1. INTRODUCTION

A number of motivations exist for saving seed at the community level, including crop biodiversity preservation, food sovereignty of local seed, and the potential for improved crop production. Beyond traditional farmer seed saving practices, many opportunities exist for small to medium-sized seed bank entities operated at the community level. This article will summarize some of the work of ECHO and its experiences partnering with community seed banks throughout Southeast Asia.

To date, ECHO has engaged with a growing network of community seed banks (CSBs) throughout the region, serving at the community and/or local NGO level. Current partner seed banks range in scale and scope but share in their implementation of low-cost appropriate technologies for the storage of their seeds.

Given the proper facilities necessary to store seeds long-term, whereby low temperature and low humidity are kept stable over time, it is very possible to store most orthodox seeds for several years at a time in the tropics (Harrington, 1972). Unfortunately, implementation and maintenance of the proper facilities can be very costly, and many existing seed bank and gene bank facility options do not satisfy the needs of many smaller organizations or communities. Thankfully, many diverse options currently exist, with varying levels of investment for a wide range of facilities, from expensive high-tech models, down to low-cost, low-maintenance models. In partnership with these member seed banks, ECHO has assembled over the years, a growing body of knowledge related to appropriate seed storage practices and techniques. This paper will attempt to summarize some of these best practices and appropriate technologies.

2. A NETWORK OF COMMUNITY SEED BANKS IN SOUTHEAST ASIA

2.1. Learning from a Network of Seed Bank Managers

In 2017 the first Asia Regional Seed Bank Managers Forum was hosted at the ECHO Asia Impact Center in Thailand, with 20 participants coming from seven different countries. This provided opportunity and insight into several unique models of community seed banks in the region, as well as the opportunity to discuss the success and challenges experienced by each individual community seed bank. Throughout the discussion, it was noted that community seed banks offer many beneficial services to the communities within which they reside, from the quality seeds they offer to the informal agricultural extension and rural advisory services they make available.

Figure 1 below summarizes a group-wide SWOT Analysis of the 20 individual community seed bank managers present, illustrating the most commonly reported strengths, weaknesses, opportunities, and threats perceived for community seed banks of the respective managers.

Strengths	**Weaknesses**
Local Wisdom	Funding
Support from NGOs	Lack of government seed policies
Offering additional agrigultural training opportunities	Poor seed inventory management systems
Connected to existing network of seed banks	Limited labor/staff
Creativity	
Opportunities	**Threats**
Serving organic markets	Multinational corporations
Local crop improvement	Loss of crop biodiversity
Training local partners	Seed ownership laws
Income/profit	Reliance on hybrid seeds
Advocacy with government	Local disaster

Figure 1: Summary of SWOT analysis responses from the 2019 Regional Seed Bank Managers Forum, ECHO Asia Impact Center, Chiang Mai, Thailand.

It should be noted that these responses speak to the multi-dimensional role of a community seed bank, bringing a challenging combination of technical and organizational needs. It was evident that these community seed bank managers are required to become adept in many areas beyond the biological aspects of seed saving; learning to address finances, organizational structure, seed inventory systems, as well as communication with local farmers and local government.

To date, ECHO Asia has spent considerable effort working with its regional seed bank partners, with a specific focus on the physical infrastructure necessary for storing seed. While managers noted several weaknesses and further opportunities for their respective seed banks, seed storage infrastructure was not readily listed, speaking to the traction having been made in these areas. While storage practices at partner seed banks can always be improved, it was encouraging to note that this initial hurdle is being overcome, through some of the techniques highlighted below.

The following sections highlight some of the 'best practices' that have been successfully studied and implemented with network seed bank partners serving across different countries in Asia, most of which are small in size and serve only the communities surrounding them. Many seed bank network partners operate on limited budgets, in rural or remote areas, and are typically supported by a local NGO or an association of churches. The typical community seed bank partner within the ECHO Asia network will typically operate under the supervision of only one or two dedicated staff members and an assortment of volunteers.

3. AFFORDABLE COLD STORAGE ROOM OPTIONS

A wide range of seed cold storage facilities exist, including affordable options appropriate for the local community level seed bank. Often falsely perceived to be cost-prohibitive, options for the community level or local NGO entities do exist. Listed below is a survey of some of the different options available to aspiring community seed banking entities. It should be noted that any cold storage unit can serve purposes beyond simply storing seeds, with the potential for multi-purpose use along the fresh produce cold chain as well the potential for storage of medical supplies and other potential applications.

3.1. Insulated Air-Conditioned Cold Rooms

At ECHO, we operate our own range of seed storage facilities at our various seed banks around the world, from a high-tech, walk-in climate-controlled cold storage room, and a retrofitted refrigerated shipping container, to a low-cost, foam-insulated cold room cooled with a standard split-unit air conditioning system. Table 1 (see page 31) is a summary of the various cold storage facilities that exist within ECHO alone, including size, temperature level, and cost estimates.

3.2. Natural Building Techniques

While each of the aforementioned systems has been shown to be effective in storing seeds for our needs over time (Motis, 2016), even our lower-cost long-term cold room options do not adequately address the very real question of how seed storage facilities may be replicated at a farm or local community level. Though we have learned how to bring down costs considerably to establish low-budget facilities, these options remain out of reach for many communities and smaller organizations, and each example currently relies on the need for an uninterrupted supply of electricity, among other barriers. In an attempt to address these ongoing questions, much of our recent effort at the ECHO Asia Impact Center has shifted into improving the practicality and cost-effectiveness of seed storage options for small community seed banks, and on to the individual farmer level.

Building on ideas observed in the field, and storage ideas passed onto us by ECHO network members, we have attempted to verify the effectiveness and practicality of various options using natural earth-building techniques. A small research experiment was implemented throughout 2018 (Jan–Dec) at the ECHO Asia Seed Bank in Chiang Mai, Thailand, and was replicated by one of ECHO's Community Seed Bank network members in Myanmar.

3.2.1. Natural Building Seed Storage Research Results

This experiment was initiated to test the effectiveness of natural building seed storage techniques, specifically within the Southeast Asian context whereby temperature and humidity are higher than the climates in which these facilities were originally implemented.
Lablab (*Lablab purpureus, L.*) seeds were stored over the course of one year inside of three different natural building facilities, including (1) an earthbag house, (2) a hillside bunker, and (3) a buried clay cistern (Figure 2). Seeds were placed inside of each facility, with half of the seeds (a) sealed airtight in jars using a modified bicycle vacuum pump (Bicksler, 2015; Thompson, 2016), while the other half remained (B) unsealed in paper bags. Four separate batches were placed in each storage facility in order to test seeds for seed moisture content and germination rates over the course of months 3, 6, 9, and 12, with containers remaining unopened until testing during their respective months.

In addition to testing and monitoring the viability of these seeds stored in these environments, data loggers were placed inside and outside of each of these facilities to track storage conditions over one year, specifically temperature and relative humidity. Data loggers recorded temperature (°C) and relative humidity (%) every hour.

3.2.2. Earthbag Houses & Buried Clay Cisterns

Climatic data collected from the Thailand site generally indicated a significant stabilization of temperate and humidity in the earthbag house and buried cistern compared to outside ambient conditions. Temperatures did not drop considerably on average in each of the storage facilities (~23°C), but daily temperature swings were reduced substantially. For reference, our climate-controlled, walk-in seed storage cold room in Florida maintains an average temperature of 6°C, with very little fluctuation, while our spray-foam insulated cold room using a standard split-unit air conditioning system maintains an average temperature of 15°C.

While temperature control and stability were improved, relative humidity inside of these natural building facilities was very high overall, even during the dry season. The underground facilities, and the buried cistern, recorded high rates of humidity, while the free-standing earthbag house appeared to have achieved lower overall humidity.

On their own, natural earth-building facilities appear to be poor storage facilities for seeds, due to their high rates of relative humidity, which can quickly deteriorate seed quality. In both Thailand and Myanmar, seed germination rates of unsealed seeds after sowing plummeted from 94% to less than 50% within just three months of storage. Measuring seed moisture content showed a rapid absorption of moisture in seeds, due to the high moisture content of the air within, rising from 12% seed moisture content to over 20% in just four months. Similar results were found when storing seed in vacuum-sealed and unsealed conditions in a refrigerator, where humidity is similarly high (Croft, 2012).

	Facility	Location	Detail	Size (m)	Average Temp.(°C)	Cost (USD)
Long-Term Storage Options (5+ yrs)	ECHO Global Farm Cold Room (large)	Florida, USA	High-tech, climate-controlled, walk-in cold room	6 x 3 x 2.5	5	35,000
	ECHO Global Farm Shipping Container Cold Room	Florida, USA	Retrofitted refrigerated shipping container, single split-unit A/C system with Cool-Bot sensor	2.5 x 3 x 2.5		10,000
	ECHO Asia[1] Cold Room (large)	Chiang Mai, Thailand	Foam insulated, double split-unit A/C system with Cool-Bot sensor	8 x 5 x 2 .5	15	5,500
	ECHO Asia[1] Cold Room (small)	Mae Ai, Thailand	Foam insulated, single split-unit A/C system with Cool-Bot sensor	5 x 3 x 2	6	3,250
Year-to-Year Storage Options (1-5 yrs)	Earthbag Storage House	Mae Ai, Thailand	Clay and rice hull filled bags, stacked walls with thatched roof	4 (diam.) x 1.7h	23	750
	Hillside Bunker	Mae Ai, Thailand	Dug-out storage nook, in primarily clay-based hillside or sloping land	2 x 2 x 1.5		80
	Buried Cistern	Mae Ai, Thailand	Large glazed ceramic cistern designed for water storage, buried up to the rim in the ground		23	20

Table 1: Economic summary of various seed bank cold room and seed storage options used at ECHO's various sites around the world. 1Further details available in ECHO Asia Note #27 (Price, 2016).

4. LOW-COST SEED STORAGE TECHNOLOGIES

4.1. Vacuum Sealing

When in combination with vacuum-sealing, seed germination rates in each of the three natural building storage facilities remained steady over the course of one year, maintaining germination rates above 90% at the end of the experiment (Figure 2). Seed moisture content held constant for the most part as well, increasing less than 2% over the year. It was therefore illustrated that natural building storage rooms must be used in combination with other appropriate seed storage technologies. Similar results were found when storing seed in vacuum-sealed and unsealed conditions in a refrigerator in northern Thailand, where humidity is similarly high (Croft, 2012).

Vacuum sealing has also been shown to be effective in the management of stored grain pests, through the removal of oxygen and the suffocation of bruchid grain pests (Lawrence et al., 2017). However, it is the removal of humidity in the air that most directly impacts the storage capability for orthodox seed, especially important in parts of the world that experience high levels of relative humidity throughout the year.

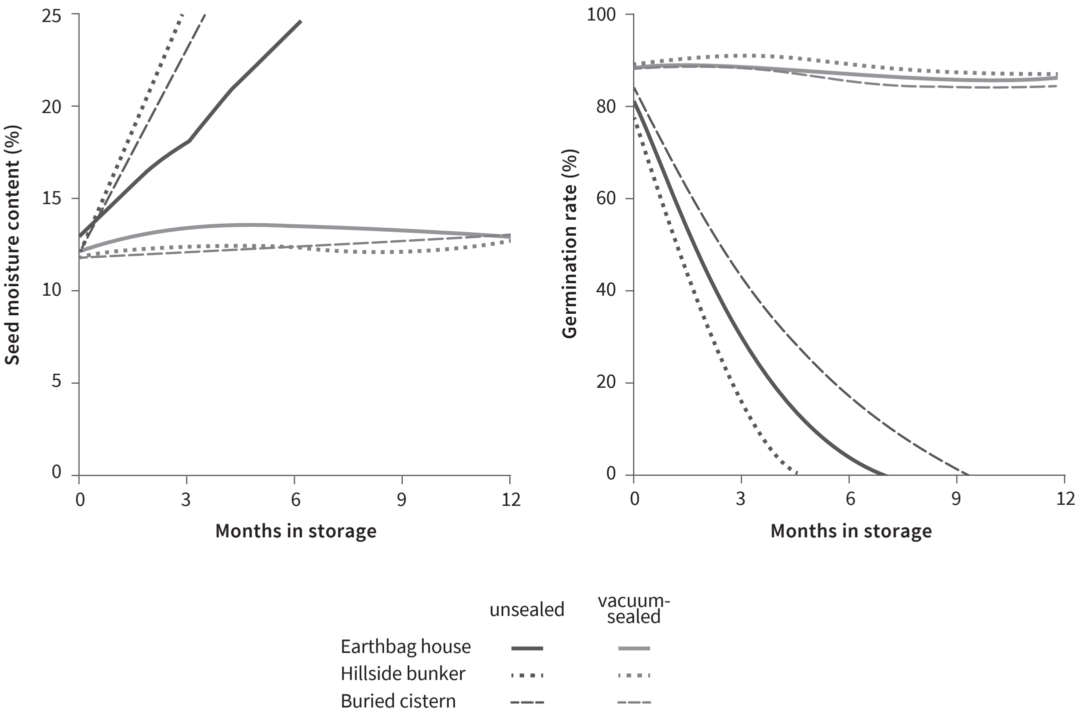

Figure 2: Seed moisture content (%) and germination rates (%) of vacuum-sealed and un-sealed seeds stored in earthbag houses, hillside bunkers, and buried cisterns.

4.1.2. Modified Bicycle Vacuum Pumps

A variety of affordable vacuum sealing machines currently exist on the market, several of which have been used around the world at ECHO and its regional offices. However, in an effort to bring appropriate seed saving technologies to the most remote and resource-constrained areas of Southeast Asia, whereby electricity is expensive or intermittent, a search for affordable alternative practices was undertaken.

It was found that a simple bicycle air pump can easily be modified, by flipping the inside valve to pull air instead of pushing it. This simple apparatus can be used to pull a vacuum on a variety of containers including glass jars and recycled glass or plastic bottles. Further instruction on how to build a modified bicycle vacuum pump can be found in *ECHO Technical Note* #93, titled 'Vacuum Sealing Options for Storing Seeds: Technologies for Small-Scale Seed Bank' (Motis, 2019). Even cheaper vacuum sealing appropriate technology can be made using a modified medical syringe for the same effect.

Figure 3: An example of a low-cost 'modified bicycle vacuum pump,' whereby the flow of air has been reversed to pull air instead of push it.

4.2. Hermetically Sealing with Desiccants (drying agents)

Many other seed storage options exist beyond vacuum sealing, including a wide variety of 'desiccants' that can be included within seed storage containers for the purpose of absorbing moisture and keeping seeds dry. Numerous materials have been experimented with, including charcoal, bentonite, silica gels, lime, and a variety of plant-based botanical powders. These desiccants are most effective when used in combination with 'hermetic sealing,' whereby containers are kept airtight. In hermetic sealing, air is not removed like in vacuum sealing, it simply excludes any additional outside air.

For the purposes of this paper, we will focus on two particular technologies that have been shown to be effective.

4.2.1. Zeolite Drying Beads®

Zeolites are a natural rock material known for their absorptive capacity. Having a unique structure, these highly porous materials have the potential to absorb humidity from the air when stored in hermetic containers. Also known as 'molecular sieves', these materials are often used as water filtration materials, but can be dried and used to absorb humidity from air inside of seed storage containers. One advantage of Zeolite Drying Beads® is that they can be redried and used repeatedly.

One downside of Zeolite Drying Beads® is that they have the potential to pull humidity from the air and even additional moisture from the seeds themselves. A recent ECHO research experiment showed that okra seeds stored with Zeolite Drying Beads® were dried down so low that within just one month, germination rates dropped from 90% to 40%, killing most of the seed by month 12. While Zeolite Drying Beads® have the potential to be a very useful technology when used properly, they can be risky due to their potential to over-dry seed.

4.2.2. Calcium Oxide

Calcium Oxide (CaO), also commonly referred to as hydrated lime or quick lime, works in a similar manner to that of Zeolite Drying Beads® albeit for a fraction of the cost, and more widely accessible to the average farmer. Comparing seed stored with Calcium Oxide to seeds stored with Zeolite Drying Beads® in the experiment mentioned above, it was shown that Calcium Oxide was much less likely to over-dry seed but effective enough to remove excess moisture in the air in the storage containers, making it a very useful and affordable desiccant for stored seed.

5. CONCLUSION

Many different appropriate technologies and practices exist for improving the effectiveness of seed storage. The examples listed above are by no means an exhaustive list, and only highlight some of the technologies that have proven successful within ECHO's network of seed bank partners.

While there are numerous examples of different seed storage facilities available, and numerous examples of seed storage container technologies that exist, it is the combination of improved storage infrastructure and seed storage container technology that seem to be most effective. At ECHO we have found that if we can reduce and stabilize ambient temperature through low-cost natural building techniques, and address humidity control through vacuum sealing or the use of an effective desiccant, orthodox crop seeds can be effectively stored over several years.

Storing seeds from 2-3 years becomes a significant advantage to farmers that are used to only storing seed from year to year, from harvest to planting, typically less than a single year. By simply increasing the length of seed storage from one year to three years, we can offer farmers and communities more planting options year to year, allowing for better crop rotation and increased diversity of species that can be grown.

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NOTES

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