Vacuum Sealing vs. Refrigeration: Which is the most effective way to store seeds?

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Introduction
Storing seeds in the tropics can often be difficult; with high temperatures and humid conditions, seeds lose their ability to germinate quickly. Many techniques for seed storage exist, from the high-tech standards of gene banks to simple methods used by villagers for saving their own seeds. All have their strengths and weaknesses, but when balancing costs and resources, which methods are really the most...
The three key factors that determine the rate of seed deterioration in storage are: oxygen pressure (amount of oxygen with the seeds in storage), seed moisture content, and temperature (Roberts, 1973). An increase in any of these factors will lower the storage life of the seeds, and as a general rule any increase of 1% moisture content or 10°F (5.6°C) in storage will halve the storage life of the seeds (Bewley and Black, 1985). Each factor contributes to seed decay in specific ways, and minimizing these conditions is critical to effective seed storage.

The goal of this research was to evaluate two seed storage options: vacuum sealing and refrigeration. Vacuum sealing is a relatively low-cost method that requires few inputs after an initial investment. Sealing helps conserve seed quality by minimizing oxygen presence and exposure to ambient humidity, thereby keeping seed moisture content low. Refrigeration minimizes temperature, but can also be expensive to maintain in tropical conditions. We used five tropical seed varieties to compare the effects of these storage methods over the course of one year; our goal was to use the outcomes of this study to help prescribe storage conditions for this seed bank and others like it around the world.

Experimental Design

We compared five different crop species grown in the tropics: tomato (Solanum lycopersicum 'Juliet 1437'), pumpkin (Cucurbita moschata 'Nang Kaang Kot'), moringa (Moringa oleifera 'Local Mix'), lablab bean (Lablab purpureus 'Chiang Dao'), and amaranth (Amaranthus cruentus, 'USDA PI 606767'). Each species was chosen to represent a different kind of crop, but each species also fills a different role in the agricultural development work of the ECHO Asia Seed Bank. Tomatoes are used as income-generating cash crops and have been promoted by the Thai government as an alternative to the opium poppy (Anderson, 1993). Pumpkin is a cucurbit, a staple among local people, but especially important to poorer families for nutrition (Anderson, 1993). The moringa tree is growing in recognition due to the exceptional nutritional content of its leaves (Oduro et al., 2008), and lablab bean is used as a green manure/cover crop while the seeds themselves also provide protein, vitamins and minerals (Kabir Alam
et al., 2008). Grain amaranth has great potential for increasing food security because of its drought-, heat-, and pest-resistant qualities (Ronoh et al., 2009).

Seeds were stored in one of four treatments: paper packets/non-refrigerated, paper packets/refrigerated, vacuum sealed/non-refrigerated, vacuum sealed/refrigerated (Table 1). Seeds were sealed together based on species and storage treatment, then tested after 0, 3, 6, 9, and 12 months of storage; all seeds were evaluated for germination rate, mean time to 50% germination, seed moisture content, and field emergence. Both germination rate and mean time to 50% germination were calculated from petri dish germination of 20 seeds in laboratory conditions, while field emergence measured germination in potting soil. Seed moisture content was determined by grinding seeds to a fine grit before drying for 15 hours at 100\(^\circ\) C. All tests had four replications, for a total of 400 packets of seeds.

Table 1. Experimental design showing different moisture and temperature regimes created by the four storage methods.

<table>
<thead>
<tr>
<th>Storage Method</th>
<th>Vacuum sealed</th>
<th>Paper Packets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Refrigerated</td>
<td>Constant moisture</td>
<td>Constant temperature</td>
</tr>
<tr>
<td>Non-refrigerated</td>
<td>Constant moisture</td>
<td>Fluctuating moisture</td>
</tr>
</tbody>
</table>

Results

Over 12 months of storage, many patterns emerged as the seeds slowly deteriorated. The method of seed storage had a highly significant effect on seed quality over this period (p < 0.0001), but the type of seed was an equally important factor. The combination of refrigeration and vacuum sealing was the best storage method for each of the aspects of seed quality we measured: germination rate, mean time to 50% germination, moisture content, and field emergence. However, the relative importance of vacuum sealing and refrigeration was not the same for each of these measures.

Differences between storage methods were most evident in the germination rate data, as there was an almost 20% drop in germination rate between each storage treatment by the end of the experiment (Figure 1). Although refrigeration and vacuum sealing together was the most effective method for
preserving germination capacity, overall, vacuum sealing alone was more effective than just refrigeration. Germination rates in the field largely mirrored these results, though with more variability due to the nature of the measure. These results show that vacuum sealing may be a more effective seed storage technique than refrigeration, especially for preserving the capacity of seeds to germinate in the lab and the field.

The outcomes for mean time to 50% germination were slightly different. As Figure 2 shows, refrigeration without sealing was slightly more effective than vacuum sealing without refrigeration at conserving a lower mean time to 50% germination (faster germination). These results suggest that storage methods affect various aspects of seed quality differently. While vacuum sealing was more effective than refrigeration at conserving seeds' capacity to germinate, it may be less useful for promoting the speed of germination. For the majority of seed quality measures, however, vacuum sealing proved to be the more effective way to conserve high seed viability.

Figure 1. Average germination rate by storage treatment over the 12 months of storage. Error bars represent ± 1 SE of the mean
While vacuum sealing never had any negative effects on seed moisture, refrigeration in combination with paper packets (fluctuating moisture) did dramatically increase seeds' moisture contents (Figure 3). The combination of high humidity in the refrigerator (sometimes as high as 98%) with paper packets that actively absorbed this moisture meant that the paper packets/refrigerated treatment had significantly higher seed moisture than any other treatment. This means that while refrigeration on its own may be a useful seed storage tool, storing seeds for long periods of time without a way to control moisture (e.g. vacuum sealing) is a poor choice for keeping seeds dry.
Differences in seed species were also critically important for determining rates of seed degradation. While some seeds were particularly prone to rapid degradation in storage, others maintained high seed quality even when stored at ambient conditions. Matching seeds to their individual requirements will most efficiently allocate resources, though this requires a thorough knowledge of each seed type.

Throughout the 12 months, lablab seeds maintained a higher germination rate than other seed types across all treatments (Figure 4), which may indicate that lablab bean, and perhaps legumes in general, do not require as many resources for storage. Both moringa and tomato, on the other hand, distinguished themselves as performing poorly in almost every measure. Pumpkin seeds generally fell in the middle range for most measures, and may be a good standard by which to gauge other seeds' quality in storage. The amaranth seeds were prone to erratic performance and though generally strong in mean time to 50% germination, amaranth had some of the lowest germination rates in the field. Ultimately, field performance is the most important test for seed quality, indicating that amaranth might be a seed species that requires more careful storage.
Summary

While our results were not always consistent across all seed species and storage methods, several trends emerged that can be applied at seed banks and village level seed saving in the developing world. When available, the combination of vacuum sealing and refrigeration can contribute to preserving high seed quality in storage. If you had to choose one storage technique, vacuum sealing alone is generally more effective than refrigeration alone. Avoid storing seeds in permeable packaging (such as paper packets) in the refrigerator, which will decrease stored seed viability. For best results, vacuum sealing can be performed with commercial, residential sealers, and low-tech, low-cost methods like the bicycle pump-turned-vacuum sealer (see http://www.echonet.org/data/sites/2/Documents/OuagaForum2010/VacuumTirePump.pdf, pictured below).

Currently, ECHO Asia Seed Bank stores all seed species in vacuum sealed packages in an air-conditioned room. While the air conditioning does not keep seeds at refrigerated temperatures, it does help to minimize both temperature...
and humidity in the seed storage room. This slows the rate of deterioration and has proven to be an effective method for seed storage in these conditions. Appropriate village-level climate controlled structures (when used in conjunction with vacuum stored seeds) may include pits in the ground or earthbag structures (watch for this in future EANs). Our research has helped determine optimal storage methods for this seed bank, and we hope that it can be used to help others minimize costs while maximizing the storage life of their seeds.

Works Cited


The Crop Genetic Pump: A Possible Task for NGOs

R.L. (Dick) Tinsley

Editor: Dr. Dick Tinsley is an Emeritus Professor with Colorado State University. With decades of experience as an advisor to smallholder agriculture development projects, he was worked in numerous locations across Asia and Africa. In this article, Dr. Tinsley draws upon his experience regarding locations where governmental certified crop seed development and distribution programs remain insufficient to meet agricultural demands and suggests a concept that he refers to as the "Crop Genetic Pump" to show how the non-governmental sector might facilitate access to seeds of improved varieties.

Introduction

In the overall economic environment common to most developing countries, the government usually attempts to provide civil services, including agricultural support services, similar to those provided by developed countries. This normally substantially exceeds the limited revenue funds and results in many programs being more on paper than in reality. When possible, important services such as these are deferred to Non-Government Organizations (NGOs). Included among these are crop variety development, seed multiplication and distribution efforts. NGOs working with smallholder communities have an excellent opportunity to informally provide a valuable and durable service by obtaining small quantities of advanced breeding lines for the important crops produced in their host communities. They can then multiply them within the community for sale and distribution to the smallholder farmers at or near market seed prices instead of at certified seed prices, which typically cost twice as much.

Financially Suppressed Economies and Financially Stalled Governments

The overall problem and common denominator for most developing countries is the generally financially suppressed economy in which prices for locally produced consumer goods may be one-third to one-fifth of developed countries, while salaries and wages may be only one-twelfth of developed countries (http://lamar.colostate.edu/~rtinsley/FinancialSuppressed.htm). Such disproportion results in considerably larger percentages of income or subsistence production being used just to meet basic requirements, typically stated at 80 percent of income in developing countries compared to 12 to 15 percent of income for developed countries. Since taxes to fund government services must come from discretionary income and not for essential subsistence spending, there is a very limited tax base in most developing countries. What taxes that are collected are mostly committed to meeting the contractual personnel obligations for officers in terms of salary and fringe benefits such as retirement, healthcare and often housing. The bottom line is that there are virtually no operating funds for managing programs in terms of vehicles for travel, per diem, fertilizer for conducting trials and demonstrations; even paper, pens, printer cartridges, etc. can be in short supply.
This results in governments that are financially stalled with the officers spending most of their time in their offices, consuming copious amounts of tea and looking for additional funding to hopefully do some field work ([http://lamar.colostate.edu/~rtInsley/FinanciallyStalled.htm](http://lamar.colostate.edu/~rtInsley/FinanciallyStalled.htm)). They also tend to focus on informal supplemental income opportunities, including supplemented salaries for being seconded to development NGOs for the duration of an externally funded project, gratuities for services provided, and consulting for larger farmers who can afford to pay reasonable consulting fees ([http://lamar.colostate.edu/~rtInsley/InformalIncome.htm](http://lamar.colostate.edu/~rtInsley/InformalIncome.htm)). The latter would be a conflict of interest in most developed countries, but is completely legal and encouraged in most developing countries and at least gets officers in the field.

**Impact on Crop Variety Development and Seed Distribution**

The highly financially stalled government can have serious consequences for crop variety development and resulting seed multiplication and distribution ([http://lamar.colostate.edu/~rtInsley/VarietyImprovement.htm](http://lamar.colostate.edu/~rtInsley/VarietyImprovement.htm)). Without financial resources from tax revenues to fully undertake crop variety improvement programs, but still in need for fresh genetic material with the potential for higher yields and increased pest resistance, many countries defer virtually all of their variety development work to collaborative programs with the International Agriculture Research Centers (IARC), most of which are part of the Consultative Group For International Agriculture Research (CGIAR). This would include well known centers such the International Rice Research Institute (IRRI) and the International Maize and Wheat Improvement Center (CIMMYT).

Since the IARCs' outreach programs are on contract to some international donors, they have all of the operating funds needed and do most of the work. Efforts concentrate more on screening imported lines distributed by the IARCs core program, such as IRRI's International Network for Genetic Evaluation of Rice (INGER) program, than on any actual genetic crossing. However, this effectively gets new crop materials into the country that are evaluated under local research conditions and ultimately released as various named varieties. Because these varieties are evaluated under ideal research conditions, they may not be fully suitable for harsher farm conditions. Host country officers do effectively assist and collaborate with this work. Without such collaborative programs with the IARCs, variety development would virtually stall and research officers would barely be able to maintain their limited germ bank collections. This was the case for rice in both Tanzania and Ghana where some research stations have not received any fresh genetic material for over 10 years.

Once varieties are released, multiplication and distribution efforts are left to the host governments and may get tied up in the overall financial stall. While virtually all developing country governments have seed multiplication and certification programs in place or on paper, they often really do not have the capacity to provide more than a small percentage of the seed requirements, nor the staff and operating funds needed for an international standard certified seed program to fully supervise seed farms. For
example, during the late 1990s Thailand's seed division was only able to produce enough soybean seed for one-sixth of the acreage planted. Even then they were not able to sell all that was produced. This left over five-sixths of the soybean acreage planted to market seed that was informally distributed and had long ago lost its varietal identity. In Kenya a couple years ago, two new varieties of soybean developed in conjunction with IITA were released. However, inquiries to various research stations of the Kenya Agricultural Research Institute (KARI) failed to identify any seed multiplication effort to make the new varieties available to farmers, large or small.

Farmers are thus mostly left on their own to plant whatever seed they can obtain, either from their own retention of the previous harvest or seed purchased in the local markets (usually referred to as "market seed"). Such practice most likely accounts for over 90 percent of all seed planted worldwide, including self-pollinated crops like wheat in developed countries. For example, in Colorado it is estimated that only 25 to 30 percent of the wheat acreage is planted to certified seed, with the balance planted to retained seed.

Similarly, in Nigeria there is only one seed certification team in Kano State, the major agricultural state in the north of the country, and none in other states. This team is expected to make three field visits per growing season to each certified seed field, usually less than a hectare in area. These visits are scheduled for:

1. The beginning of the season to make certain different varieties are physically sufficiently separated to avoid accidental contamination,
2. The middle of the season to check for crop uniformity, and
3. The end of the season to check cleanliness and collect a germination sample for testing.

This is an impossible task for one team with limited operational resources, whose members are almost beholden to their clients just to get around. Thus one has to wonder how much of this certification program is on the honor system, perhaps assisted with some nice gratuities to provide the certification (such as for the non-uniform sorghum field on a seed farm in Nigeria shown in Fig. 1). As seed certification will double the value of the crop, this also raises the question as to whether certified seed produced under these administrative and budgetary constraints is substantially better in quality than seed informally sold or distributed in village markets and by local agro-dealers, particularly to justify the nearly double price as well as the additional transportation costs.
The situation results in farmers being wisely reluctant to invest in certified seed and relying almost entirely on market seed. It also means the variety identity is usually lost, although some local distinctions may be possible related to the best use, etc.

The net result is that virtually no fresh genetic material is entering most smallholder communities through designated channels; only limited amounts arriving through informal sources. However, particularly where "traditional" varieties are being grown that are morphologically low yielding, and perhaps more prone to pest attacks, there is a continual need for fresh genetic material to be introduced to farming communities. Also, unless a clear yield difference between certified seed and market seed of the same variety can be demonstrated, seed can easily be multiplied within a community, avoiding the need to import large volumes of nationally certified seed. Demonstrating a potential yield advantage of certified seed over market seed can be difficult, as shown in Table 1 with a comparison of yields from seed sourced by the project (institutional) vs. regular farmer-produced seed for three rice varieties in Tanzania.

<table>
<thead>
<tr>
<th>Variety</th>
<th>Source</th>
<th>Yield (t/ha)</th>
<th>Source</th>
<th>Yield (t/ha)</th>
<th>Source</th>
<th>Yield (t/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Project</td>
<td>1.72</td>
<td>Project</td>
<td>0.61</td>
<td>Project</td>
<td>1.44</td>
</tr>
<tr>
<td>Farm 1</td>
<td>Farmer 1</td>
<td>2.24</td>
<td>Farmer 4</td>
<td>1.11</td>
<td>Farmer 7</td>
<td>0.97</td>
</tr>
<tr>
<td>Farm 2</td>
<td>Farmer 2</td>
<td>2.01</td>
<td>Farmer 5</td>
<td>1.01</td>
<td>Farmer 8</td>
<td>1.68</td>
</tr>
<tr>
<td>Farm 3</td>
<td>Farmer 3</td>
<td>1.56</td>
<td>Farmer 6</td>
<td>0.42</td>
<td>Farmer 9</td>
<td>2.28</td>
</tr>
<tr>
<td>Ave.</td>
<td>Ave.</td>
<td>1.89</td>
<td>Ave.</td>
<td>0.79</td>
<td>Ave.</td>
<td>1.59</td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>Std. Dev</td>
<td>0.57</td>
<td>Std. Dev</td>
<td>0.57</td>
<td>Std. Dev</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Source: Developing Smallholder Agriculture: A Global Perspective
**The Crop Genetic Pump**

In the general absence of an effective, reliable and official channel for seed multiplication and distribution, the introduction of needed fresh genetic material to smallholder communities can be fairly easily done by NGOs working with host communities. The process would be to simply contact the local office of any IARCs collaborating with the national variety improvement research programs for the crop in question, ask them for small amounts of seed for promising varieties, and take the packs of seed back to their host communities for multiplication and distribution. Most IARC offices are conveniently located at major agriculture research stations and are often happy to share small quantities of seed, perhaps a
kilo or half kilo, of promising lines. They may request that you participate in a verification or validation trial. This is generally the last formal stage of variety development prior to release, and is expected to be done on farmers' fields throughout the country; IARCs are often looking for volunteers to conduct such trials. The opportunity should be welcomed and encouraged, and the requested data should be collected and readily returned.

Once a number of new varieties have been acquired, seed can be multiplied within the community, possibly in conjunction with one of the community-based family enterprises already serving as agro-dealers. While the initial seed is being grown, encourage farmers to review and appraise the plant type, yield, and quality of the seed, and to comment on their likes and dislikes. Be sure to maintain identities of the varieties or breeding lines, and clearly label them in the field. At the end of the first season, the farmer-preferred lines can be further multiplied, while those not appreciated can be quietly discarded. With most grains and grain legumes, the multiplication ratio is over 50 to one. Thus if you start with a kilo of seed, the first season will yield 50 kg, and the second season 2500 kg. In three seasons there should be sufficient seed to blanket a community, at least to the extent that farmers are interested in growing the crop.

Be sure to keep varieties separated and clearly identified. The ultimate objective is to have three or four different varieties of major crops being grown in a community in nearly equal amounts. Growing several varieties of the same crop within a community can prevent a complete catastrophe when pest resistance breaks down for one variety (which periodically happens as pests can mutate and overcome a crop breed's mechanism for resistance).

The process of introducing and evaluating potential new crops only needs to be done every three or four years. It takes time to develop new varieties, and there would not be major changes in available lines in less than four years.

By operating a genetic pump for the benefit of community members, an NGO can have a durable impact on the community with limited effort and risk; just some patience for a couple of seasons as the initial seed multiplication is done. If, in the process, some traditional lines are replaced with modern high yielding lines, and if the seed is continually saved and planted in the community, the impact will endure well past the typical time for NGO-facilitated poverty alleviation projects.

The genetic pump is really about enhancing and expediting the informal flow of genetic material that takes place around official channels. This takes place slowly as farmers move around visiting distant relatives, participating in farmer study tours, etc. or through verification trials that are conducted in communities.
An example includes IR 1561, an early IRRI-developed line that was used in several on-farm verification trials in the mid-1970s. Farmers liked the line and it became widely used in the Philippines and persisted for over 20 years, even though it was never formally released or recognized as a variety (and thus no certified seed is available).

Another example is the popular rice variety called Zambia in southern Tanzania, mentioned in Table 1 above. Neither the Zambian nor Tanzanian rice programs have any varieties so designated. Apparently someone from Tanzania who crossed the border into Zambia liked the variety and grabbed a small amount of seed. Having lost track of the original variety name, after taking the seed back to Tanzania, the variety was referred to as 'Zambia.' Similarly, in Nigeria farmers were growing a rice variety they referred to as Cameroon. In Afghanistan the most commonly identified wheat variety is MexiPak. This is an original that Nobel laureate Norman Borlaug developed over 60 years ago, prior to the project he was working on in Mexico having evolved into CIMMYT. The variety was intended for use in Pakistan but apparently leaked across the border. Again, it is not recognized by the Afghanistan government. Local officials may not appreciate this, but the reality is that they cannot do anything about it.

Managing a Crop Genetic Pump
Avoid Hybrids:
One restriction on the crop genetic pump concept is that it is for self-pollinated crops and not hybrids. This quickly reduces the prospects for hybrid maize and sunflower varieties that cross-pollinate. Hybrid varieties are F1 initial crosses and are still segregating with each generation, so fresh certified seed is needed each planting season. Otherwise, the resulting crop will be highly non-uniform and low yielding. For this reason it is normally ill-advised to emphasize the use of hybrids in smallholder communities since the logistical supply will be difficult to maintain once a project with external support ends. However, there are composite varieties for maize and sunflower that have been grown and rogued (i.e. selecting out any undesirable non-uniform plants) for several generations until they have become uniform. The yield potential is maybe 10 to 15 percent less than hybrids, but yields will be stable from season to season [Ed: The EDN 88 article 'Hybrid Maize Revisited' discusses how hybrid corn varieties have been recycled or creolized over a number of years by Mexican farmers; http://www.echocommunity.org/resource/collection/CAFC0D87-129B-4DDA-B363-9B9733AB8F1/edn88.pdf]. More appropriate crops for genetic pumps would be rice, wheat and most legumes, as well as plants that are vegetatively propagated like cassava and sweet potato.

Involve Local Agro-Dealers:
It might be helpful to get local agro-dealers involved, particularly those indigenous to the community and what may best be referred to as "Community-Based Family Enterprises (CBFE)" (Fig. 3). Dealers such as these are a permanent part of the...
Fig. 3. Typical family run agro-dealership in Thailand

also more durable than cooperatives or other socially desirable multiple-owner enterprises promoted by donors (which are generally too administratively cumbersome to be competitive with the family enterprises). Agro-dealers are also better qualified to deal with any government objections, including paying any gratuities if occasionally necessary.

Seed Quality: One of the main reasons for official objection to a crop genetic pump program would be concern for seed quality. There are basically three components to seed quality: genetic purity, good germination rates and cleanliness. All three components can be easily dealt with in a smallholder community through the facilitation of an NGO.

Of these, the most important is genetic purity, which is easily maintained with self-pollinated crops provided that seed from different varieties does not get mixed. While often stated as a concern, genetic impurity is most likely rare with anyone interested in getting into the village seed business (as envisioned with the genetic crop pump approach).

For genetic purity, it is recommended to remove any off-types (i.e. plants with undesirable traits). This is usually done in the field just before harvest by removing the off-types that are typically unusually tall. Or it can be done after harvest if plants are cut with a sharp sickle at a uniform height from the ground as the Lao farmer is doing in Fig. 4. However, note that even after training many seed
The next seed quality component is **good seed germination**. Normally, most crops, if stored in a reasonable manner, will bridge the off-season with sufficiently high germination to be of acceptable quality. If grain weevils are a problem, they may be controlled without resorting to fumigation simply by sun-drying the seed on mats. The resulting heat will cause the weevils to become uncomfortable and drive them to seek the shade under the mat. Afterward, when the seed is re-bagged, the weevil population will be drastically reduced [Ed: For more tips on controlling post-harvest pests, click on the following ECHOcommunity.org link http://www.echocommunity.org/resource/resmgr/a_to_z/azch10st.htm#Table].

Ideally, the desired germination rate should be in the order of 90 percent or more. In the case of lower germination (e.g. down to about 60 percent), it is recommended to simply increase the seeding rate during planting to compensate for lower germination. Germination can be easily tested with a simple ragdoll test (ftp://ftp-fc.sc.egov.usda.gov/GA/PMC/JLW/ragdoll.pdf). The results of such a simple test may not be up to the standards of temperature-/humidity-controlled seed labs, but would be sufficient for rural communities just interested in producing the next crop.

The last major concern would be cleanliness and seed that is free of foreign material. Contaminated seed is not really a major problem as much as an inconvenience. Unless a seed drill is used for planting, which is rare for smallholder communities, any foreign materials simply increase the bulk that has to be handled. Weeding requirements may also increase if part of the foreign material is weed seed. However, simple grain cleaners could be used to clean the seed and remove any chaff and weed seed, as well as stones or mud clods (Fig. 5). This technique could also be used to clean grain and perhaps command up to a 10 percent bonus in grain sales (this is the amount that traders often have to discount grain purchases to compensate for both the amount of trash and the cost of removal). A clean bag of grain may represent the first value added to a grain crop and can be done right in the community by the family enterprises dealing with seeds and grain purchases.
the grain from being blown away.

(http://lamar.colostate.edu/~rtinsley/CleanBag.htm). Again assisting the CBFE to obtain such seed- and grain-cleaning equipment would be a good task for an NGO and provide a lasting contribution that would assist in increasing income in the community.

All of these seed quality concerns can easily be included in simple training programs for those interested in becoming involved. This might also be a good opportunity for micro-credit programs to assist with some of the initial costs for multiplying the seed or equipment for cleaning the seed.

Official Reaction
Official reaction to a crop genetic pump initiative that effectively bypasses government programs may be a blunt rejection and general condemnation about the quality of the seed, with all kinds of potential concerns for genetic contamination, poor germination and impurities in the seed. Those promoting government programs, including the regular use of certified seed, have a vested interest perspective. However, governments generally do not have the manpower or financial resources to undertake and effectively provide the necessary services or the resources to enforce or restrict such programs. Thus, while there may be verbal protests, nothing more should be expected. The overriding need is to get the fresh genetic material into the community and available to the farmers so that they can benefit from the wider choice of varieties and prospects for higher yields and income.

Intellectual Property Rights
Many new varieties and specific genes are now being patented by the large international agro-business, with an expectation of royalties being paid for their use, even from impoverished smallholders. As a result, there has to be some concern for violation of patent rights, etc. However, the IARCs are supposed to be supported primarily by public funds from donor countries and operate in the public domain. Thus the variety plant material that they generate is assumed to be public domain and freely available to anyone in need, particularly host developing countries; both public and private sector alike.

Summary
While the crop genetic pump concept discussed in this article is mostly conceptual, it is worth trying where national programs do not have the financial or personnel resources to provide comprehensive variety improvement, seed multiplication and seed distribution programs. The key component is for NGOs working in smallholder communities to obtain small amounts of seed for different varieties and breeding lines and to work with indigenous family enterprises to multiply the seed within the host community for sale to farmers through the normal village marketing channels. This may require some minimum training on how to manage seed in a rural setting [Ed: An excellent ECHO resource related to
seed storage is "Seed Saving Tips & Technologies" by Dr. Tim Motis; [http://www.echocommunity.org/resource/collection/E66CDFDB-0A0D-4DDE-8AB1-74D9D8C3EDD4/Seed_SavingTips_&Technologies.pdf]. If the government or other public institutes do not have the capacity to provide an influx of new varieties, then they should allow the NGOs to assist. Such an undertaking could have positive long-term impact on the host communities that will extend well beyond the limited duration of NGO externally-funded projects.

Ed: Dick Tinsley is the author of the book Developing Smallholder Agriculture: A Global Perspective. He also manages the website [www.smallholderagriculture.com](http://www.smallholderagriculture.com), and teaches the continuing education internet course Challenges to Smallholder Agriculture ([http://villageearth.org/training-and-consulting/online](http://villageearth.org/training-and-consulting/online)).

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### ECHO Asia Myanmar Agriculture Workshop

**Dates:** October 30-November 2, 2012 (Tuesday-Friday)  
**Location:** Myanmar Baptist Convention Conference Hall, Yangon

**Cost:** $100 per person or $80 per person for groups registering 5 or more. The training fee includes lodging at the Myanmar Baptist Convention compound, lunch and two breaks daily and transportation to select field trip sites.

**Language:** Burmese and translated English

**Description:** Co-hosted by the Myanmar Baptist Convention, World Concern Myanmar and the ECHO Asia Impact Center, this workshop will offer practical learning opportunities and discussions related to:

- Natural farming methods using indigenous microbes: (half day)
- Biochar for agriculture and mitigation of climate change (full day)
- Climate change: Practical responses to the effects on agriculture (half day)
- Grain amaranth: production and food preparation methods (half day)
- Alternative energy approaches for Myanmar: biogas, improved stoves, improved
charcoal production (half day)

Seed Exchange:
All attendees are invited to bring seeds or other propagatable materials (root or stem cuttings, etc.) of valued and special crops from their areas. These might include outstanding non-hybrid varieties of rice, corn, fruit and vegetables. Anyone who brings seeds and/or plant materials will be eligible to receive similar materials in exchange.

Post-workshop tours on Nov. 2 (Friday) - Possible tour options include:

- Myanmar Baptist Convention Farm - Demonstrations related to sustainable livestock and crop production and appropriate technology/alternative energy
- Shan Maw Myae - Organic noni production and beverage enterprise
- Vegetable and Fruit Research and Development Center
- Government vermiculture site
- Organic vegetable production
- Perennial crop enterprise

To register or to receive more information contact: mbc.cssdd@gmail.com or echoasia@echonet.org

ECHO Asia Alternative Energy and Appropriate Technology Symposium
Alternative Energy and Appropriate Technology for Community Development: What Really Works?

January 22-24, 2013
Holiday Garden Hotel & Resort, Chiang Mai, Thailand

Cost: 3,900 baht per person (approximately $125). The training fee includes lunch and two coffee breaks daily at the hotel as well as transportation to afternoon field trip sites.

Program and topics: The symposium will include three morning plenary sessions offered by professional development workers, researchers and business persons related to the following topics:
- Small-scale gasifier stove technology using agricultural by-products as fuel
- Biochar production for water filtration, amending soils and carbon sequestration
- Community-level solar energy technology
- Micro-hydro generation of electricity
- Biogas
- Improved production and utilization of charcoal fuel

Site visits will take place each afternoon to:

- The Mae Jo University Alternative Energy Center
- Locations featuring farmer-developed appropriate technology
- The Pun Pun Sustainable Living and Learning Center to see efforts related to alternative housing as well as biochar production and utilization

Lodging: Symposium participants are responsible for their own lodging arrangements during the meeting. The Holiday Garden Hotel & Resort, [www.holidaygardenhotel.com](http://www.holidaygardenhotel.com), is offering the following accommodations and rates:

- Tower Wing - Superior 850 Baht/night (including American breakfast) - Twin or Single basis
- Garden Wing - Superior 850 Baht/night (including American breakfast) - Twin or Single basis

For more details about lodging at the Holiday Garden Hotel & Resort contact Khun Panyata at [info@holidaygardenhotelandresort.com](mailto:info@holidaygardenhotelandresort.com).

To register or to receive more information about the symposium contact [echoasia@echonet.org](mailto:echoasia@echonet.org).

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2013 ECHO Asia Agriculture and Food Production
Workshop - Philippines

Dates: March 5-7, 2013
Location: Aloha Farm, Puerto Princesa City, Palawan

Cost: $100 (4,200 pesos) per person or $80 (3,360 pesos) per person for groups registering 5 or more. The training fee includes a buffet lunch and two breaks daily.

Description: Co-hosted by Aloha Farm and the ECHO Asia Impact Center, this workshop will offer practical learning opportunities related to:

- Small-scale livestock production
- Improvement and maintenance of soil fertility
- Production and application of natural foliar fertilizers
- Production and application of bokashi (fertilizer/soil amendment made from kitchen waste)
- An introduction to Asian perennial vegetables
- Agroforestry systems for the production of non-timber forest products
- Intensive nursery management
- Value-added natural processing of farm products.

Seed Exchange: All attendees are invited to bring seeds or other propagatable materials (root or stem cuttings, etc.) of valued and special crops from their areas. These might include outstanding non-hybrid varieties of rice, corn, fruit and vegetables. Anyone who brings seeds and/or plant materials will be eligible to receive similar materials in exchange.

Local accommodations: Contact Aloha Farm regarding accommodations at the farm and nearby (mik@mozcom.com).

Flight Details: Eight flights daily from Manila to Puerto Princesa City and three times per week from Cebu. Hotels have van pickup service from and to airport.

To register or to receive more information about the symposium contact echoasia@echonet.org
The ECHO Asia Impact Center operates under ECHO, a non-profit, Christian organization that helps you help the poor to produce food in the developing world.

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