Strengthening Informal Indigenous Seed Systems in Southeast Asia

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Collaborating Authors

*Ricky M. Bates – Corresponding Author
Associate Professor of Horticulture
Department of Horticulture, Penn State University
University Park, Pennsylvania, USA
rmb30@psu.edu

Abram J. Bicksler
Coordinator of Sustainability Research and Instructor
International Sustainable Development Studies Institute
Chiang Mai, Thailand

Richard Burnette
Director
ECHO Asia Impact Center
Chiang Mai, Thailand

Thomas Gill
Assistant Director of International Programs
Office of International Programs, Penn State University
University Park, Pennsylvania, USA

Laura Meitzner Yoder
Senior Fellow and Instructor
International Sustainable Development Studies Institute
Chiang Mai, Thailand

Vincent Ricciardi
Research Technician
ECHO Asia Impact Center
Chiang Mai, Thailand

Yongyooth Srigiofun
Vice President for International Affairs
Mae Jo University
Chiang Mai, Thailand

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Introduction

With support from USAID's Horticulture Collaborative Research Support Program (Hort CRSP), Educational Concerns for Hunger Organization's Asia Impact Center (ECHO Asia), Maejo University, Thailand, and the Pennsylvania State University (Penn State) initiated efforts in 2010 to begin strengthening indigenous informal seed systems in northern Thailand and Cambodia. Their project was premised on several well-established facts:

- Informal seed systems, such as farmer-to-farmer exchanges and farmer self-saved seed, are critical components of resource-poor farming systems in Southeast Asia.
- A rich diversity of underutilized species function within these systems, particularly among the hilltribe communities of northern Thailand and Khmer farmers of Cambodia.
- Current efforts to conserve, improve, and disseminate local species are inadequate, and the indigenous knowledge surrounding this local seed system is threatened, and/or eroding.
- To optimize these informal seed systems we need to better understand their characteristics and improve local stakeholder capacity, and access to information, technology and high quality seed.

A key project goal was the characterization of the informal seed system, including the documentation of indigenous annual and perennial vegetable crops, seed germination and vigor, and seed pathways and "germplasm gatekeepers", along with compiling local knowledge surrounding the system. Additional objectives included facilitation of the exchange, preservation and dissemination of important genetic resources identified during farmer community surveys, and improvement of local access to quality seed and important seed information.

Background

Study Sites

Renowned Russian botanist, Nikolay Vavilov, included a region of Asia stretching from the Indian subcontinent through Southeast Asia as a "key global center of origin" for food

crops. More than 170 crop species originate in this geographic swath. Near the center of this region is where this project's three survey sites are located. Two of the survey sites lie near the Myanmar border of northern Thailand with the third located in the Svay Riang Province of southwest Cambodia, adjacent to the border of Vietnam.

The two northern Thai survey sites, in the Chiang Mai and Chiang Rai Provinces, are both made up of clusters of upland communities. The Chiang Mai communities are largely ethnic Palaung with a minority of Lahu residents. The ethnic composition of the Chiang Rai survey site is somewhat more diverse, including three distinct Lahu groups (Black, Yellow and Red) as well as the Akha ethnic group. In contrast, the population of Svay Riang study area in Cambodia is entirely Khmer.

Although language and religious differences separate the Thai hilltribe groups, they share similar recent histories and livelihoods. All of the communities in the two Thai survey sites were established by migrants from Myanmar, with most of the recent migration having taken place between the early 1960s and mid 1980s. In comparison, the Khmer survey collaborators in the Svay Riang area are native to a region that is still recovering from the Vietnam War and subsequent Khmer Rouge regime (1975-1979).

Along the Myanmar border, many but not all of the hilltribe migrants have attained Thai citizenship. Being located in a remote, mountainous region, they have limited access to educational opportunities and other services that are more readily available elsewhere in the Kingdom of Thailand. However, electricity and improved roads are being extended into the uplands. In Svay Rieng, although citizenship and documentation are not issues for residents, rural roads remain unpaved and electricity has yet to arrive in the farm communities.

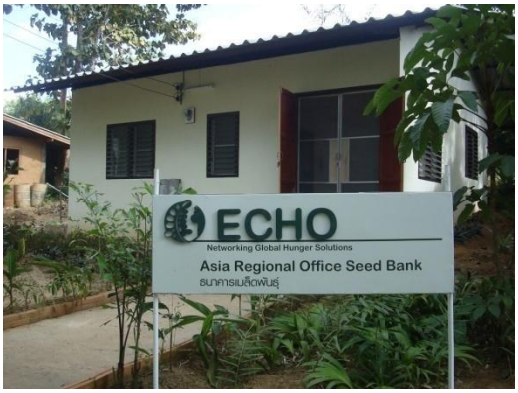
Compared to the Thai national average of 141,480 baht ($4,716), average annual incomes for hilltribe families in the two Thai survey areas are approximately 28,229 baht ($941) per year. In Svay Rieng, incomes are considerably lower with the average earnings of a family of nine being approximately $220.

In Thailand, with both community clusters located on public land (national park and reserve forest), there is no formal land ownership or secure land tenure. Although many

residents seek outside supplemental employment, agriculture remains the main local livelihood with upland rice and/or cash crops such as maize and legumes grown in rotational or permanent hill fields. Only a small minority of farmers in Chiang Rai have access to rainfed paddy. However, practically all of the households in the two Thai survey areas tend home gardens, particularly during the rainy season, and gather wild vegetables from the forest. Food insecurity remains a risk for many.

In general, the residents of Svay Rieng have limited access to farmland, mainly growing paddy rice during the rainy season. Household food production is generally at the subsistence level or less. Most households also tend small home gardens. Compared to northern Thailand, there is much less forest cover in southeast Cambodia, resulting in limited access to wild foods. Malnutrition continues to be a common contributing cause of death among children in the province.

ECHO Asia Seed Bank



ECHO Asia Seed Bank

The ECHO Asia Seed Bank is one service of the ECHO Asia Impact Center, which works closely with smallholder farmers in Asia to be more productive, especially in the area of agriculture. The ECHO Asia Impact Center functions primarily as a technical support organization helping community development organizations and workers operate more effectively. One of the key goals of ECHO Asia is to increase the availability of appropriate seeds of select regionally important crops among development workers, to encourage regional seed saving and sharing, and to determine the availability of other plant material that may be of local agricultural significance. The ECHO Asia seed bank is currently a repository of over 170 master accessions of locally important species, and is located in Mae Ai District on the campus of the Upland Holistic Development Project (UHDP) in northern Thailand near the border with Myanmar.

Approach

The field research in each of the three successive locations consisted of one month of data collection on farmer seed practices, collection and germination testing of farmer-saved seed, and culminated in a seed fair event among the villages involved in that region's research. To complete the necessary field research, a team of American and Thai or Cambodian field researchers lived in each village community for one month.

Household Interviews and Participatory Activities

The research team met with village leaders, and held a total of 171 semi-structured, observation-based interviews concerning seed-saving practices and seed acquisition with ten percent of each village's households, spanning all socioeconomic strata. Researchers met with women's groups in each location, and invited them to participate in the subsequent seed fair events.

Picture card sorting in Cambodia

Participatory and visual techniques also proved helpful in this research with multiple language groups who had limited literacy. The research team compiled a set of large picture cards of the 77 most common annual and perennial vegetables in the region, to have a common visual reference point to obtain the crop names in local languages and to discuss the presence and use of those vegetables in each village region. Participatory maps identified households of various socioeconomic levels, and illustrated seed pathways and trade networks. Gender card sorting for various activities related to the seed

Trade map from Cambodia village PRA activity

system was an enjoyable way to talk about household-level divisions of labor. A timeline constructed with a multi-generational group in Cambodia traced changes in the villagers' agricultural system and stages of interaction with the commercial seed industry over six decades.

Seed Fairs

Seeds from Chiang Dao Seed Fair

Three seed fairs were held, one in each village cluster, in the months of January, February and March 2011. The first was held in Pang Daeng Nawk community of Chiang Dao province, the second in the remote Mae Yao area of Chiang Rai province, and the third in Svay Rieng province, Cambodia. Each seed fair was set up as a half-day event including registration and a brief training/discussion related to improved seed production and saving techniques. In all, more than 150 people participated from nearby communities and brought a total of more than 500 packets of seeds for exchange, in addition to the provision of ECHO-Asia seeds to exchange. Participants were divided into village groupings to allow each person to introduce seeds that they had brought. Afterward, seeds of particularly interesting varieties from each village were described to the large group, generating much interest in seed swapping.

Seed Accession Collection and Seed Viability Testing

Farmer-innovated seed preservation and storage methods were recorded in each of the village clusters. During interviews, household members were asked to share about their various indigenous vegetable seeds, donate seeds to the ECHO Asia Seed Bank and describe their seed preservation and storage methods for all seed lots donated. Accession information for the seed lot was collected and consisted of:

1) A reference card number from species in the card sort that the household could positively identify and attach to donated seed;
2) Latin binomial, if available;
3) Local plant and variety name;

4) Approximate harvest date;
5) Any seed treatments to the seed lot before storage;
6) Storage vessel used;
7) Storage location;
8) The number of seeds received for each seed lot.

After sorting and discarding diseased or damaged seeds for each of the seed accessions collected, 25% were stored in paper packets to be taken to the ECHO Asia Seed Bank in Mae Ai, Thailand, for further identification, evaluation, and potential grow-out and distribution; 50% were designated as seed material to be used in a seed viability experiment; and 25% were stored in paper packets to be used in a seed vigor experiment at the ECHO Asia Seed Bank (Figure 1). The minimum usable number of seeds per accession was 40 and the maximum usable numbers of seeds per accession for the viability and vigor experiments were 200 and 50, respectively. Any additional seeds above this threshold were added to the ECHO Asia Seed Bank.

Seed viability experiments were conducted at the village-level to procure real-time germination data while the social surveys were being conducted and to stimulate interest in simple research methodologies within the village. A seed germination cabinet was constructed using an aluminum kitchen cabinet (122x77x41cm) insulated with foam sheets. Constant temperatures (28-30C) and high relative humidity suitable for seed germination were achieved by using two 11W compact florescent bulbs in bases attached above each shelf in the cabinet and powered with a 120W solar array connected to a deep-cycle battery and DC-AC inverter. A simple

Seed Germination Cabinet

fifteen-minute increment timer provided modulation of the on/off cycle for the florescent tubes to achieve constant temperature and relative humidity (See EAN #8, January 2011).

Seed germination (the emergence of the seedling root) using plastic petri dishes was used to determine farmer-saved seed viability. Seeds were checked for germination one day after beginning the experiment and then every-other-day, removing and recording the number of germinated seeds. Seed viability as percent germination and mean time to 50% germination were calculated for each accession, plant family, and village cluster. Additionally, vigor experiments were conducted at the seed bank using potting mix and the 25% of the seed lots put aside for vigor determination.

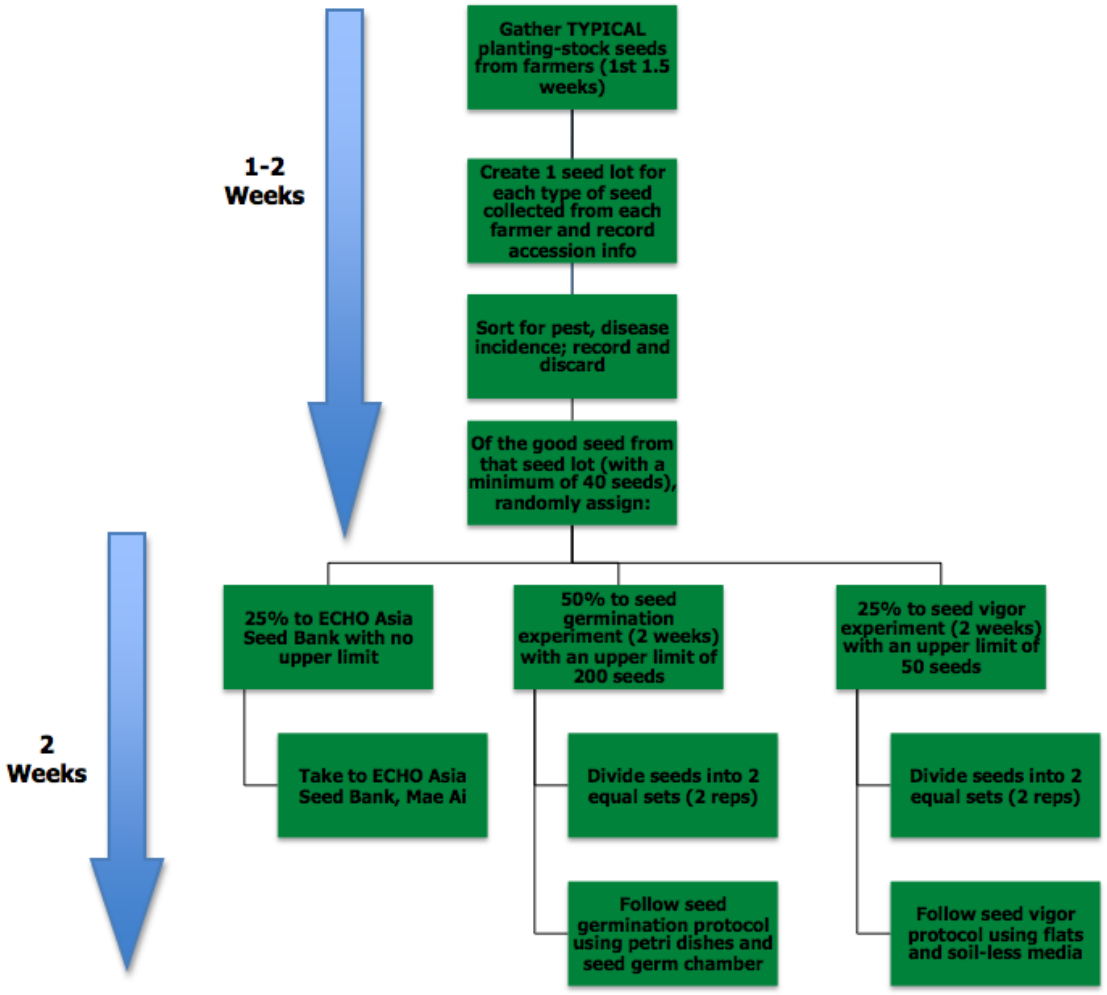


Figure 1. Seed viability testing flowchart.

Findings

Seed Saving in Rural Southeast Asian Communities

Seed Fair Participant

All farmers in the study villages save most of their own vegetable planting seed, and for the Thai villages the farmers save nearly all of their own planting seed as many of their primary preferred crops are not commercially available. In Cambodia, increased access to commercial varieties in recent years has driven greater reliance on purchased seed. In both regions, purchasing planting seed holds higher prestige than saving one's own seeds. Farmers save planting seed from bulked seed post-harvest, and few practiced any level of in-field selection or pre-storage selection for seed size or health, visible damage to seed coats, or pest infestation. The most common method of post-harvest seed drying and pest prevention is storage on open baskets over the hearth. While some sun-drying of seed was observed, some farmers reported that sunlight was harmful to seeds and avoided this process. Unlike the communities in Thailand, Cambodian farmers practiced more outdoor seed storage of seeds, in trees.

Underutilized Species Identified

Underutilized species are central to local seed systems and play an important role in smallholder farmer livelihoods. Many of these lesser-known species have significant untapped potential for commercialization. A key impact of the project was the documentation of important indigenous annual and perennial vegetable crops in the survey villages (Tables 1, 2, 3). It is notable that much of the robust diversity present within the northern Thailand food system is due to perennial species used as vegetables. Locally important perennial plants often contribute to family nutrition in significant ways, but are sometimes overlooked during inventories of underutilized indigenous vegetables. This is particularly true if the species are foraged from the wild,

versus tended in garden plots or farmer's fields. Underutilized perennial species are also important from an ecosystem sustainability perspective. In northern Thailand, fields of hill tribe farmers tend to be steep and highly erodible. A shift to more conventional annual crop species would present numerous challenges to the long-term productivity and sustainability of the hill tribe farming system. Table 1 provides a list of some important underutilized perennial species resulting from this survey.

Histories of Seed Saving

Seeds figured largely in villagers' own narratives of their histories, identities, and migrations. Interview and timeline analysis revealed key distinctions about the different village clusters, the events that defined them as a people and as a community, and their reliance on indigenous knowledge and the informal seed system. Many northern Thai communities have relocated multiple times from other regions, even across international borders from Myanmar, China and Laos. The Cambodian communities had experienced a particularly traumatic history under the Pol Pot regime and the changes following the demise of the Khmer Rouge. All communities had been directly affected in some way by violence, revolution and uprisings, and their current seed-saving practices and agricultural systems reflected these experiences of uprooting and migration, including impacts from the extensive Vietnam War.

In one northern Thai community, the following narrative encapsulates how people recounted their own histories of agriculture and migration, through stories of preserving, losing, and regaining seeds:

> *A 77-year-old Palaung man recalled his family moving on foot from a village in the Shan State of Burma in 1944, due to population and pest pressure. They took indigenous germplasm from several rice and corn varieties as well as from "seven most important crops of the Palaung tribe: two types of cabbage (pak gaad), cilantro, lablab beans, two types of cucumbers, and bit juk juk." Upon resettling, they were able to start a family garden with these seeds near their house and plant an intercropped field of rice and vegetable crops. In the early 1980s the family fled military encroachment and strife, taking with them these seven vital vegetable varieties that were the same genetic lineage from their village in the*

Shan State, and they moved with many other refugees to a densely settled area of Doi Angkhang, Thailand. After only one planting season in Doi Angkhang, they came to the Chiang Dao District with the same heritage seeds that they were able to grow and save on Doi Angkhang. They moved to a small village and were able to have ample and fertile land if they small patches into the neighboring forest. Here they tried to plant their heritage seeds but the only seeds that would grow [possibly from altitude difference] were a few varieties of rice and corn. During this readjusting and resettlement period the family asked for seeds from other families that had been in the area longer and were more established. Following traditional custom, they were able to receive their neighbors' seed varieties without having to pay a fee or exchange any goods. For five years, the family was able to plant in the forest gardens to produce their heritage corn and rice as well as intercropped vegetables they received from neighbors. Then just before harvest time, the villagers were accused of planting on conservation land and their crops were burned. Hence, there was no crop that year and the last of the heritage seeds were destroyed. The villagers were then instructed to relocate, and a timber plantation was planted in that area. After being forced off of the land, they came together as a community and with help from local volunteer teachers they gathered money to purchase for their houses and small-scale agriculture. They began again to ask for seeds from neighboring villages and cousins to resupply their seed stocks with familiar vegetables that would produce in their new home region. Slowly over time this village has grown into 58 families with an abundance of home garden production.

Gender Roles in the Informal Seed System

Gender analysis conducted in all three village clusters revealed women's dominant role in the informal seed system. There were no activities in the informal seed system identified by both men and women as ones that were exclusively performed by men. On the other hand, there were many activities identified as exclusively performed by women. Figure 2 shows the breakdown of individual seed system activities for each village cluster. Activities such as planting, selecting, cleaning and drying the seeds were typically in the female domain, giving women exclusive access to seeds at the sowing and post-harvest stages. Meanwhile, activities such as weeding and harvesting, which required a lot of manual labor, typically were performed by both men and women. Both men and women were active in the sourcing and selling of seeds, while the only activity in all three village

clusters that fell more under the male domain was decisions about planting in Svay Rieng, Cambodia.

Diversified Kitchen Garden

This analysis also revealed the different gendered understanding of the seed system between men and women. Men and women were not always in agreement about who was responsible for each activity. By asking men and women separately about these different activities, a more nuanced picture of the gender roles in these informal seed systems emerged. Overall, the gender card sorts and household interviews revealed that women are more active than men in the informal seed system. This is due to two important reasons:

1. The **different spatial domains** of men and women. Women enjoy keeping home gardens with crops for household consumption. Keeping these gardens allows them to have a hand in providing for their households while remaining in the vicinity of their homestead for other female-assigned activities, such as childcare, cleaning and washing clothes. On the other hand, the spatial domains of men are typically away from the home, gathering forest products (in Thailand only), keeping fields, hunting and dealing with animals such as pigs, fish and chickens.
2. The **gendered division of knowledge** in these communities. Women's involvement in home gardens ensures their role as gatekeepers of knowledge about indigenous vegetable species for household use. Their day-to-day handling of a variety of locally important species facilitates their familiarity with a range of crops about which they know significantly more than men. Men meanwhile invest their time in learning about other important household enterprises that fall within their typical domains. Men on the whole did not have as keen an eye on seed selection, separation and storage from the informal system as women.

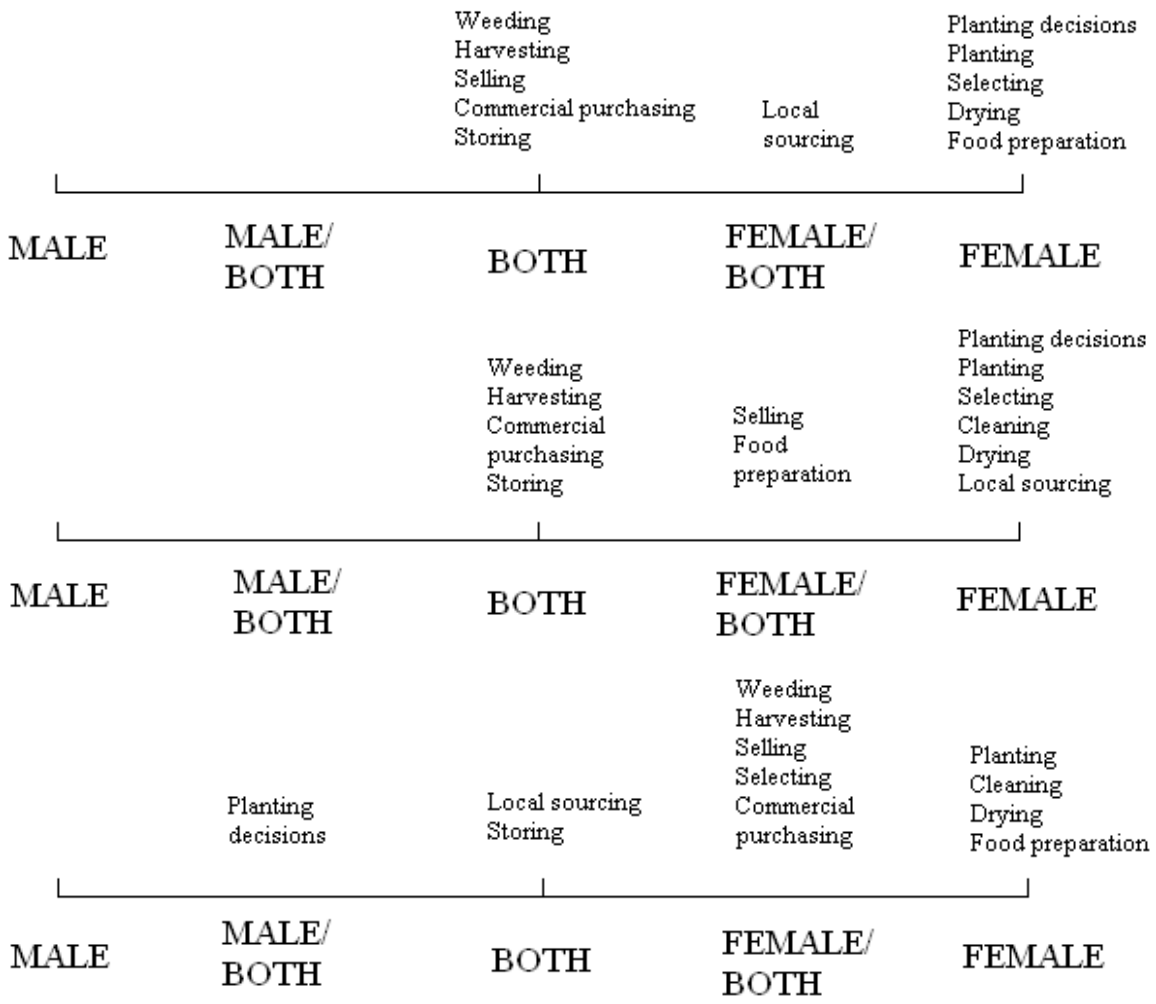


Figure 2. Gender roles in the informal seed system in Chiang Dao (Thailand) [top], Chiang Rai (Thailand) [middle], and Svay Rieng (Cambodia) [bottom] village clusters.

Informal Seed Trading

This pilot project generated rich data on village seed trading preferences and practices that will be analyzed for future publications. Early results indicate that the village clusters demonstrated similar seed trading practices. Almost without exception, farmers report that vegetable seed trade among villagers is common, and readily given whenever asked, without expectation of any payment in cash, returned seed, or produce. Farmers report requesting small quantities (a handful) of seed from relatives and neighbors on a sporadic basis. Most households saved most of their own planting seed, only occasionally needing to acquire seed from other households; these villages did not have a

defined network of seed keepers who served as primary germplasm producers and suppliers for a large number of households. Implications of these findings include the need for widely targeted agricultural development programs, with respect to agricultural biodiversity and variety production; programs cannot assume that skills or planting materials supplied to key individuals will have a direct, immediate reach to many other farmers.

Seeds are nearly always traded between people with close relationships, such as family members or friends, and the quantity of seed shared depends on the strength of the relationship between the people involved in the transaction. Non-reciprocal seed exchange is a way of building relationships; it is tradition for seeds to be shared for the common good as a way of building community. Informal seed trade between ethnic groups is common and unproblematic where community relations are good, with much of this trade and purchase occurring at local markets. Wealth stratification is evident: some farmers were more willing to ask someone for seed who is from a different ethnic group than to ask someone from a different economic stratum, and that poorer farmers were more likely to ask for seed than rich farmers.

Chiang Rai Seed Fair

The seed fairs held in each region stimulated informal exchange and uncovered patterns of trade and species that were commonly traded. The most common varieties of seeds that were brought included various types of cucumber, long bean, eggplant, field beans, okra, winged bean and vegetable lablab. However, a few uncommon varieties showed up as well, including a very large type of lima bean and some grains such as Job's tear, sorghum and millet. In the Thailand seed fairs, there was significantly more interaction and exchange of seeds among the Chiang Rai participants than among those that participated in Chiang Dao. As there is greater distance between the four communities that were represented as well as more ethnic diversity (i.e. Black

Lahu, Yellow Lahu and Akha) in Chiang Rai, seeds saved from garden crops being grown in that area might be more diverse compared to those in the Palaung communities of Chiang Dao. If so, greater crop diversity may have stimulated more interest in seed exchange.

By the time of the final seed fair in Svay Rieng, Cambodia, the event process had been well-refined and facilitated very successful and enthusiastic seed swapping among participants. The Cambodia seed fair also benefited from drawing participants from a wide geographic area, though there was little ethnic diversity as all participants were Khmer. Only 22 distinct seed species were collected at the Cambodia seed fair. Post-swap surveys indicated that on average, each participant both gave and received five packets of seed.

Seed Accession Collection and Seed Viability Testing

When all of the seed storage vessels and locations for the seed accessions were identified and cross-tabulated, it was found that plastic bags were the favored vessel for storing seeds and that above the fire was the favored location to store seeds across all twelve villages (Table 4). The favored combinations of seed storage vessels and location were storing seeds in open seed clusters above the fire or hanging plastic bags filled with seeds on the wall. Data collected from data loggers hung above village fires suggest that fire may create fluctuating temperatures and relative humidity throughout the day as the fire is stoked and allowed to cool in periodic cycles. Temperatures above a typical kitchen hearth ranged from 22.8 to 40.6C and relative humidity from 45% to 92%. Relative humidity appears to exhibit a negative relationship with increasing temperatures (Figure 3). Storing seeds above a fire may also help to prevent pest infestation, because the smoke and heat create inhospitable environments for stored seed pests, as mentioned by several villagers in interviews.

Table 4. Cross tabulation of seed accession storage location and storage vessel.

Storage Vessel	Storage Location						
		Above Fire	Hung on Wall	On or In Cabinet in Kitchen	Outside House	Total	% of Total
	Plastic Bag	7	13	3	0	23	29.9
	Open Seed Cluster	13	4	1	1	19	24.7
	Cloth Bag	9	5	2	0	16	20.8
	Paper Bag	1	2	4	0	7	9.1
	Plastic Netting	5	0	1	0	6	7.8
	Plastic Bottle	0	2	1	0	3	3.9
	In Basket	0	0	0	2	2	2.6
	Glass Bottle	0	0	1	0	1	1.3
	Total	35	26	13	3	77	100.0
	% of Total	45.4	33.8	16.9	3.9%	100.0	

Overall, 10,915 seeds representing 95 accessions of seeds were donated to the researchers for use in the ECHO Asia Seed Bank as well as in the seed viability experiment. Of these 10,915 donated seeds, 90.0% (9,532 seeds representing 80 accessions) were usable for the seed bank and experimental purposes (Figure 1). Of these accessions, the Chiang Dao village cluster donated 33 usable accessions, the Chiang Rai village cluster donated 29 usable accessions, and the Cambodia village cluster donated 18 usable accessions, where "usable" refers to an accession with enough seeds to be used in the viability experiment. Of the 79 plant picture cards that were created for the village-wide card sorts, researchers received seeds of 33.3% of the species on the cards.

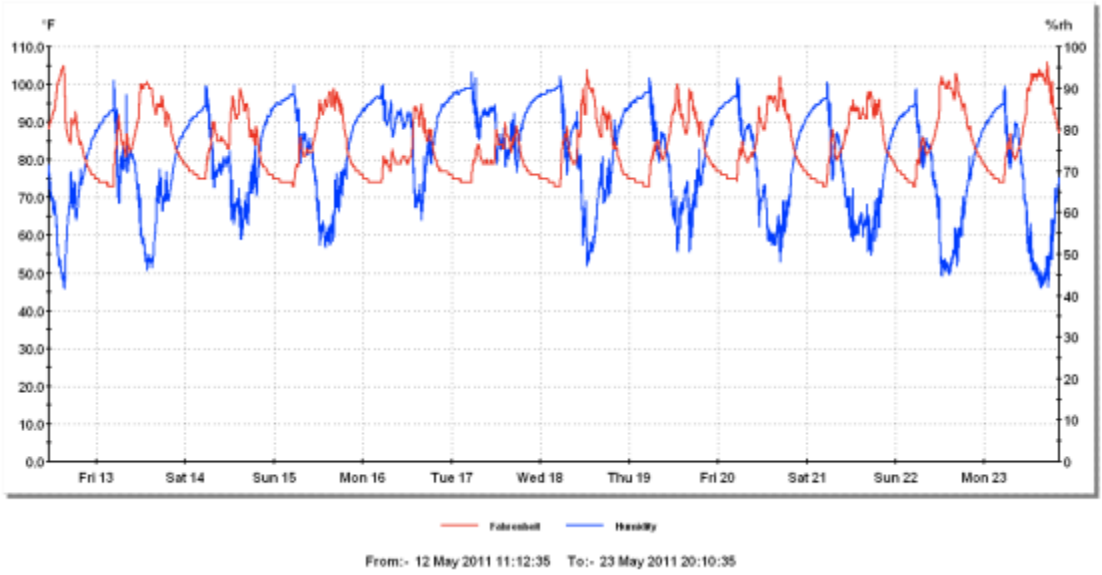


Figure 3. Temperature and relative humidity for seed storage above village fires.

Seeds across accessions from the Chiang Rai village cluster had the greatest germination rate of 64.3%, followed by Chiang Dao seeds at 54.4%, and Cambodia seeds at 44.2%. Mean days to 50% germination was lowest in seeds from the Cambodia village cluster at 5.3 days, followed by Chiang Dao at 5.5 days, and greatest in the Chiang Rai village cluster at 6.1 days. It is generally accepted that the shorter number of days to 50% germination, the better the chance of seedling survival. So, although Cambodian seeds generally had a lower viability than the other two village clusters, the seeds that did germinate may in fact exhibit greater vigor because of the lower time to 50% germination.

Across village clusters, seeds in the Fabaceae (bean) family exhibited the greatest viability of 70.8%, and seeds in the Solanaceae (tomatoes, eggplant, pepper) family exhibited the lowest viability of 21.5% (Figure 4). Each of the three village clusters were very good at saving Fabaceae seeds, and although Cambodia had the lowest overall germination rates across accessions, Cambodian villages exhibited the greatest Fabaceae viability at 85.5%. Cucurbitaceae (pumpkin and squash) seeds generally had low viability (35.5% and 41.6% in Cambodia and Chiang Dao, respectively); however, Chiang Rai seeds exhibited stellar viability at 74.2%. The great spread in farmer-saved seed viability across families may be due to inhibitory mechanisms in seeds from different seed

families or an inherent difficulty in maintaining seed viability for particular seed families in specific locations. Lessons may be learned from each of the village clusters about plant family-specific seed saving and storage methodologies for seeds that they excel at saving, as evidenced in the high rates of viability for Fabaceae seeds from Cambodia and Cucurbitaceae seeds from Chiang Rai.

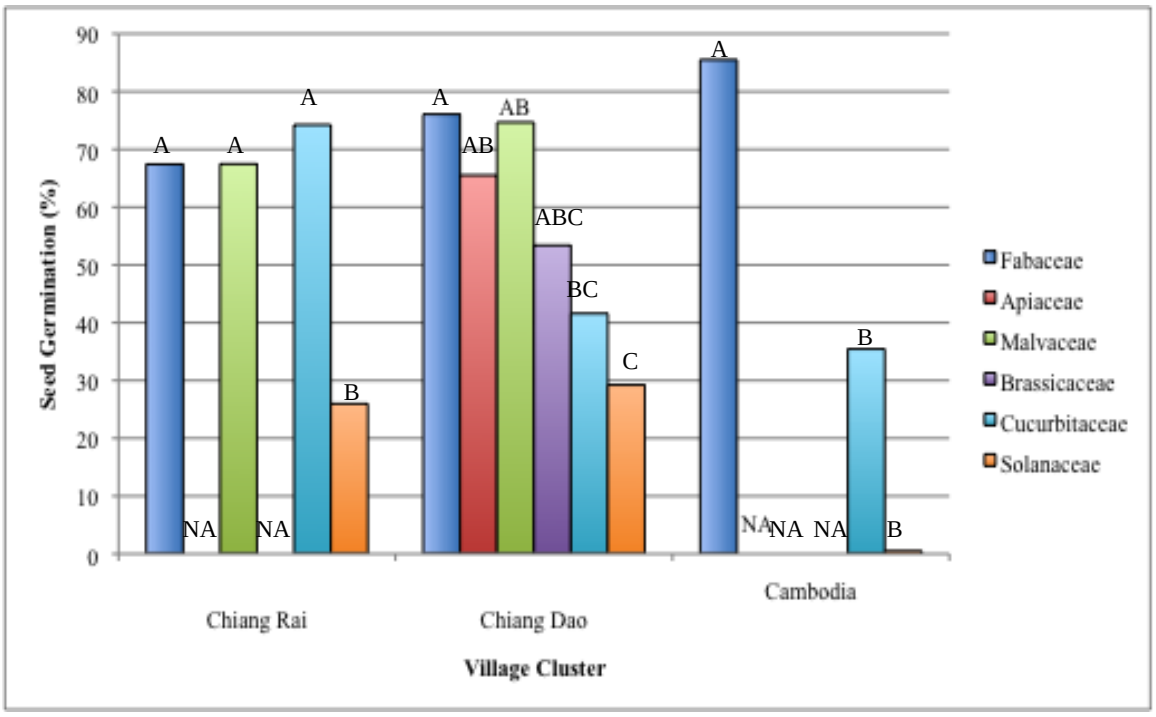


Figure 4: Effect of plant family on seed germination by village cluster. Columns with same letters are not significantly different at alpha =0.05 probability.

Conclusions

This one-year project demonstrated the value of investing in local, indigenous informal seed systems. Connecting farmers and farmer associations within the informal seed system to local non-governmental agencies and an NGO-based seed bank is versatile and has certain advantages. Many of the underutilized species revealed in the village surveys have potential and are being evaluated in a regional development context by local actors. The relationship between the local hilltribe seed system and the ECHO-based seed bank potentially improves system sustainability, offers new economic opportunities for local farmers, and increases distribution of high quality, locally adapted seed to other farmers and development workers in the region. Our results indicate that seed produced by local

farmers is generally similar in quality to seed from commercial sources. As particular species become more visible and gain in popularity, increasing supply to meet demand could be a constraint. However, this scenario does offer new market opportunities-particularly to hill tribe women farmers. Because the seed bank also distributes seed to poor farmers, as well as development workers, the system described here could also facilitate the movement and adoption of improved seed from the formal seed system. It builds upon existing local experience, knowledge and skills. It provides poor farmers who may not be able to afford commercial seed access to high quality, locally adapted varieties. And, it represents a holistic and inherently strong approach, as it relies upon partnerships and networks from all aspects of the informal seed system. It is also important to note that this project was preliminary and limited in scope and duration-weaknesses and bottlenecks identified in this study warrant further testing and modification.

This research outlines practical steps and activities for strengthening indigenous seed systems in northern Thai and Cambodian communities and potentially extends the reach and impact of valuable, locally-adapted crop species. The key to success is the adoption of a holistic approach that empowers resource-poor households and communities, fortifies indigenous seed pathways, promotes seed system best practices, and preserves and improves the rich genetic biodiversity of the system. In order to continue the strengthening of informal seed systems within the region, there is the need to expand this research and extend it into other communities and countries. This scale-up is critical to preserving biodiversity, ensuring food security and facilitating the sustainable development of these rural agroecosystems. For maximum impact, it is hoped that this methodological approach to strengthening informal seed systems can be extended into other countries in South and Southeast Asia faced with community food insecurity, including Bangladesh, Cambodia, Laos, and Vietnam.

Table 1. List of surveyed perennial plants that were identified by communities in northern Thailand and Cambodia.

#	Family	Latin Name	Common Name	Plant description - edible parts for vegetable* dishes	Regional garden status/propagation method	Presence of crops in each of the survey areas
1	Alliaceae	*Allium fistulosum*	Welsh onion, bunching onion	Perennial onion; tender leaves stir fried.	Very common; propagated by division	Ca (4), CD (4); CR (4)
2	Alliaceae	*Allium tuberosum*	garlic chives	Leaves included in various dishes.	Somewhat common; progagated by division	Ca (2); CD (0); CR (3)
3	Anacardiaceae	*Mangifera indica*	mango	Tree produces edible tender leaves	Very common; seedling production with rootstock	Ca (4); CD (4); CR (3)
4	Anacardiaceae	*Spondias pinnata*	hog plum	Tree produces edible fruit/leaf shoots	Common; propagated by seed and cuttings	Ca (3); CD (1); CR (2)
5	Araceae	*Colocasia esculenta*	taro	Herbaceous perennial produces edible stems and leaves	Very common; propagated by division	Ca (4); CD (3); CR (3)
6	Araceae	*Lasia spinosa*	spiny vegetable	Herbaceous perennial produces edible young leaves	Wild food; rarely cultivated; propagated by division	Ca (0); CD (2); CR (0)
7	Araliaceae	*Eleutherococcus trifoliatus*	climbing ginseng	Shrub produces edible tender leaves	Common in uplands; propagated by seed or cuttings	Ca (0); CD (3); CR (4)
8	Araliaceae	*Trevesia palmata*	snowflake tree	Small tree produces edible shoots and flowers	Wild food; rarely cultivated; prop. by cuttings/seed	Ca (0); CD (4); CR (1)
9	Arecacea (Palmae)	*Caryota mitis*	fishtail palm	Multi-stemmed palm with edible heart	Wild food; common Thai ornamental; propagated by seed	Ca (0); CD (4); CR (3)

10	Arecacea (Palmae)	*Calamus siamensis*	bitter rattan	Viny palm with edible shoot hearts	Wild food; sometimes cultivated; prop. by seed	Ca (0); CD (4); CR (1)
11	Arecacea (Palmae)	*Calamus viminalis*	white thorn rattan	Viny palm with edible shoot hearts	Wild food; sometimes cultivated; prop. by seed	Ca (0); CD (4); CR (3)
12	Asclepiadaceae	*Gymnema inodorum*	Kwangtung gymnema	Woody, perennial vine with edible shoots	Unknown in survey areas (grows nearby); prop. by cuttings	Ca (0); CD (0); CR (0)
13	Athyriaceae	*Diplazium esculentum*	tropical vegetable fern	Fern with edible fronds	Wild food; rarely cultivated; propagated by division	Ca (1); CD (0); CR (0)
14	Basellaceae	*Basella alba*	Malabar spinach	Herbaceous, perennial vine with edible shoots	Common; propagated by division and seed	Ca (3); CD (0); CR (1)
15	Bignoniaceae	*Oroxylum indicum*	Indian trumpet	Small tree produces edible flower/tender pod	Wild food; sometimes cultivated; prop. by seed	Ca (0); CD (0); CR (1)
16	Caricaceae	*Carica papaya*	papaya	Fruit from small tree can be eaten in salads and stir fries	Very common; seeds often saved	Ca (4); CD (4); CR (4)
17	Convolvulaceae	*Ipomoea aquatica*	morning glory	Herbaceous perennial; planted as annual; edible leaf shoots	Common (garden production); commercial seed	Ca (4); CD (1); CR (2)
18	Convolvulaceae	*Ipomoea aquatica*	aquatic morning glory	Herbaceous perennial; aquatic; edible leaf shoots	Common (ditches/ponds); propagated by cuttings	Ca (1); CD (1); CR (1)
19	Convolvulaceae	*Ipomoea batatas*	sweet potato	Viny, herbaceous perennial produces edible young leaves	Common garden/field crop; propagated by cuttings	Ca (4); CD (3); CR (4)
20	Cucurbitaceae	*Coccinia grandis*	ivy gourd	Viny, herbaeous perennial produces edible leaf shoots	Common wild food; sometimes cultivated	Ca (2); CD (1); CR (1)
21	Euphorbiaceae	*Manihot esculenta*	cassava	Woody shrub produces edible leaves (raw leaves toxic)	Common field crop; propagated by cuttings	Ca (3); CD (4); CR (4)

22	Fabaceae	*Acacia concinna*	shikakai, soap pod acacia	Woody shrub with edible leaf shoots, flowers and pods	Uncommon; propagated by cuttings	Ca (0); CD (0); CR (0)
23	Fabaceae	*Acacia pennata*	cha-om	Woody shrub produces edible leaf shoots	Wild food; common in gardens; propagated by cuttings	Ca (4); CD (4); CR (1)
24	Fabaceae	*Cajanus cajan*	pigeon pea	Woody shrub produces edible flowers and young pods	Common field and garden crop; seeds saved	Ca (3); CD (4); CR (3)
25	Fabaceae	*Lablab purpureus*	vegetable lablab bean	Herbaceous, viny semi-perennial with edible tender pods	Common garden crop; seeds saved	Ca (1); CD (4); CR (4)
26	Fabaceae	*Leucaena leucocephala*	ipil ipil	Invasive shrub; edible shoots and tender pods	Common; wild and cultivated; propagated by seed	Ca (4); CD (2); CR (1)
27	Fabaceae	*Psophocarpus tetragonolobus*	winged bean	Herbaceous, viny perennial; many parts edible	Very common; seeds saved	Ca (4); CD (4); CR (3)
28	Fabaceae	*Sesbania grandiflora*	sesbania	Small tree produces edible flowers	Common; propagated by seed	Ca (3); CD (4); CR (0)
29	Fabaceae	*Tamarindus indica*	tamarind	Tree produces edible leaf shoots	Very common; seedling production	Ca (3); CD (2); CR (4)
30	Fabaceae	*Senna siamea*	cassod tree	Tree produces edible leaf shoots and flowers	Wild food and planted; common; propagated by seed	Ca (0); CD (1); CR (2)
31	Lamiaceae	*Clerodendrum glandulosum*	glorybower	Edible leaf shoots	Wild food; isolated cultivation; propagated by cuttings	Ca (3); CD (2); CR (0)
32	Malvaceae	*Hibiscus sabdariffa*	roselle	Semi-perennial, woody, small shrub; edible shoots	Common garden plant; seeds saved	Ca (0); CD (3); CR (1)

33	Meliaceae	*Azadirachta indica*	neem	Tree produces edible leaf shoots and flowers	Fairly common; usually propagated by seed	Ca (3); CD (4); CR (0)
34	Moraceae	*Artocarpus heterophyllus*	jackfruit	Tree produces edible fruit that is cooked in curries	Very common; usually propagated by seed	Ca (4); CD (4); CR (4)
35	Moraceae	*Broussonetia kurzii*	sa lae	Woody shrub produces edible flowers	Wild food and cultivated; uncommon; prop. by cuttings	Ca (0); CD (0); CR (0)
36	Moraceae	*Ficus racemosa*	cluster fig	Tree produces edible leaf shoots	Wild food; isolated cultivation; propagated by cuttings	Ca (0); CD (0); CR (0)
37	Moraceae	*Ficus virens*	white fig; red shoot fig	Tree produces edible leaf shoots	Wild food; some cultivation; prop. by cuttings	Ca (0); CD (1); CR (0)
38	Moringaceae	*Moringa oleifera*	moringa	Tree produces edible shoots and tender pods	Common; propagated by seed and cuttings	Ca (4); CD (4); CR (0)
39	Musaceae	*Musa x paradisiacal*	banana	Edible fruit, flowers and inner core of stalk	Very common; propagated by division	Ca (4); CD (4); CR (4)
40	Phyllanthaceae	*Sauropus androgynus*	katuk/sweet leaf	Woody shrub produces edible leaf shoots	Common; propagated by cuttings	Ca (1); CD (4); CR (4)
41	Piperaceae	*Piper sarmentosum*	leaf pepper	Low growing, erect; produces edible leaves	Somewhat common; propagation by division and cuttings	Ca (0); CD (3); CR (0)
42	Poaceae	*Gigantochloa apus*	large bamboo	Edible shoots	Wild food and cult.; prop. by rhizome/culm/branch cuttings	Ca (0); CD (2); CR (0)
43	Poaceae	*Thyrsostachys siamensis*	umbrella bamboo	Edible shoots	Scattered cultivation; propagated by rhizome offsets	Ca (0); CD (1); CR (0)

44	Poaceae	*Dendrocalamus giganteus*	giant bamboo	Edible shoots	Scattered cult.; prop. by rhizome offsets and culm cuttings	Ca (1); CD (2); CR (0)
45	Poaceae	*Dendrocalamus strictus*	male bamboo	Edible shoots	Common; propagation by rhizome offsets and culm cuttings	Ca (1); CD (2); CR (1)
46	Solanaceae	*Solanum indicum*	Indian nightshade	Berry-like fruit (yellow or orange will fully mature)	Wild food and cultivated; regionally common; seeds saved.	Ca (0); CD (0); CR (0)
47	Solanaceae	*Solanum stramonifolium*	red-fruited nightshade	Yellow fruit; added to various dishes	Regionally common garden perennial; seeds saved	Ca (0); CD (0); CR (0)
48	Solanaceae	*Solanum torvum*	Thai pea eggplant	Small green fruit; added to various dishes	Common garden perennial; seeds saved	Ca (4); CD (3); CR (0)

***Any edible part of either cultivated or wild plants, typically leaves, shoots, stem hearts, flowers and fruits, that is eaten as a significant portion of a primary dish (e.g., salads, soups, curries), excluding pulses, carbohydrate-rich grains or root crops and dessert fruits.**

Table 2. List of surveyed annual plants that were identified by communities in northern Thailand and Cambodia.

#	Family	Latin Name	Common Name	Plant description - edible parts for vegetable* dishes	Regional garden status/propagation method	Presence of crops in each of the survey areas
49	Amaranthaceae	*Amaranthus tricolor*	vegetable amaranth	Both small seedlings and tender leaves consumed.	Regionally common vegetable crop; commercial seed	Ca (4); CD (0); CR (0)
50	Amaranthaceae	*Celosia argentea*	celosia/cockscomb	Leaves reportedly consumed by the Palaung in the past	Common ornamental flower; seed saved	Ca (4); CD (4); CR (0)

51	Amaranthaceae	*Spinacia oleracea*	spinach	Edible leaves	Somewhat common garden crop; commercial seed	Ca (1); CD (2); CR (0)
52	Asteraceae	*Lactuca indica*	Indian/tropical lettuce	Edible leaves; older leaves are quite bitter	Uncommon garden crop; seed saved; self-seeds	Ca (1); CD (0); CR (1)
53	Asteraceae	*Lactuca sativa*	lettuce	Raw leaves used to dip chili sauces and curries	Fairly common garden crop; commercial seed	Ca (0); CD (1); CR (1)
54	Brassicaceae	*Brassica alboglabra*	Chinese kale	Edible stalks and florets	Somewhat common garden crop; commercial seed	Ca (0); CD (2); CR (3)
55	Brassicaceae	*Brassica chinensis*	Chinese mustard cabbage	Edible leaves and vegetative heads	Fairly common garden crop; commercial seed	Ca (3); CD (4); CR (4)
56	Brassicaceae	*Brassica juncea*	mustard greens; leaf mustard	Leaves prepared in various ways	Common upland field and garden crop; seeds often saved	Ca (0); CD (3); CR (3)
57	Brassicaceae	*Brassica oleracea var. capitata*	cabbage	Edible vegetative heads	Not very common garden crop; commercial seed	Ca (1); CD (1); CR (1)
58	Brassicaceae	*Brassica oleracea var.botrytis*	broccoli	Edible leaves and florets	Uncommon garden crop; commercial seed	Ca (0); CD (0); CR (0)
59	Brassicaceae	*Brassica rapa*	turnip mustard	Edible leaves and root	Fairly common in the uplands; seeds saved	Ca (0); CD (3); CR (1)
60	Brassicaceae	*Raphanus sativus var. longipinnatus*	daikon radish	Edible leaves, seed pod and root	Fairly common; commercial seed; seeds sometimes saved	Ca (3); CD (3); CR (2)
62	Cucurbitaceae	*Benincasa hispida*	wax gourd; winter melon	Large fruit cut up and added to curries and soups	Very common field and garden crop; seeds often saved	Ca (4); CD (4); CR (4)

63	Cucurbitaceae	*Cucurbita maxima*	pumpkin	Edible fruit and shoots	Common; commercial seed; seeds saved	Ca (2); CD (4); CR (1)
64	Cucurbitaceae	*Cucurbita moschata*	pumpkin/squash	Grown in fields/gardens; edible fruit, shoots and flowers	Very common field and garden crop; seeds widely saved	Ca (4); CD (4); CR (4)
65	Cucurbitaceae	*Cucumis sativus*	cucumber	Edible fruit	Very common field and garden crop; seeds widely saved	Ca (4); CD (4); CR (4)
66	Cucurbitaceae	*Lagenaria siceraria*	calabash; bottle gourd	Edible fruit and shoots	Very common; seeds widely saved	Ca (4); CD (3); CR (3)
67	Cucurbitaceae	*Luffa cylindrica*	smooth luffa gourd	Edible immature fruit	Very common; seeds widely saved	Ca (4); CD (4); CR (2)
68	Cucurbitaceae	*Momordica charantia*	bitter melon	Edible young fruit	Common; seeds saved	Ca (4); CD (0); CR (1)
69	Cucurbitaceae	*Trichosanthes cucumerina*	snake gourd	Edible young fruit and leaf shoots	Fairly common; seeds saved	Ca (0); CD (3); CR (1)
70	Fabaceae	*Canavalia gladiata*	sword bean	Produces large pod with edible pink/red seeds	Not very common; seeds saved	Ca (2); CD (1); CR (1)
71	Fabaceae	*Phaseolus lunatus*	lima bean	Edible immature seeds, pods and leaves.	Not very common; seeds saved	Ca (2); CD (4); CR (0)
72	Fabaceae	*Phaseolus vulgaris*	French/bush/string bean	Edible tender pods	Not very common; seeds saved; commercial seeds available	Ca (1); CD (2); CR (0)
73	Fabaceae	*Pisum sativum*	sugar pea	Edible pods and vine shoots	Uncommon; seeds saved; commercial seeds available	Ca (1); CD (1); CR (1)
74	Fabaceae	*Vicia faba*	fava bean	Edible seeds	Uncommon; seeds saved	Ca (2); CD (0); CR (1)

75	Fabaceae	*Vigna umbellata*	rice bean	Planted as a green manure/cover crop; tender pods eaten	Common in certain areas; planted as field crop; seed saved	Ca (1); CD (4); CR (0)
76	Fabaceae	*Vigna unguiculata*	black bean/bush (cowpea)	Immature pod consumed	Common; planted as garden and field crop; seed saved	Ca (1); CD (4); CR (3)
77	Fabaceae	*Vigna unguiculata ssp. Sesquipedalis*	yardlong/asparagus bean	Immature pod consumed	Very common garden crop; seeds widely saved	Ca (4); CD (4); CR (3)
78	Malvaceae	*Abelmoschus esculentus*	okra	Edible pod	Common garden crop; seeds widely saved	Ca (2); CD (4); CR (0)
79	Solanaceae	*Lycopersicon esculentum*	tomato	Edible fruit	Common perennial (planted as annual); Seeds saved	Ca (3); CD (4); CR (3)
80	Solanaceae	*Solanum melongena*	common eggplant	Various types (shapes and colors) for a variety of dishes	Very common perennial (planted as annual); seeds saved	Ca (4); CD (2); CR (3)

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Table 3. List of seeds added to the ECHO-Asia seed bank collection as a result of the project.

	Scientific Name	Family	Common Name	Thai or Local Name	Seed color
From Chiang Dao					
1	*Momordica charantia*	Cucurbitaceae	bitter melon		
2	*Vigna unguiculata*	Fabaceae	bush cowpea		Black
3	*Luffa cylindrica*	Cucurbitaceae	Angle luffa		
4	*Lablab purpureus*	Fabaceae	Lablab		
5	*Mucuna pruriens*	Fabaceae	Velvet bean		Black
6	*Phaseolus lunatus*	Fabaceae	Red potato lima bean		
7	*Anehthum graveolens linn.*	Umbelliferae	Dill		
8	*Citrullus lanatus*	Cucurbitaceae	Water melon		
9	*Celosia argentea L.var.cristata*	Amaranthaceae	Common cockscomb, Crested celosin		
10	*Cucumis sativus*	Cucurbitaceae	Cucomber melon		
11	*Sorghum bicolor*	Sorghum	Millet		
12	*Vigna unguiculata ssp. Sesquipedalis*	Fabaceae	Yardlong bean		
13	*Benincasa hispida Cogn*	Cucurbitaceae	Wax gourd		White
From Chiang Rai					
1	*Phaseolus lunatus*	Fabaceae	Purple potato lima bean		purple
2	*Vigna unguiculata*	Fabaceae	bush cowpea		Brown