Annual Report

Feed the Future
Reduction of Post-Harvest Loss Innovation Lab

October 2014 - September 2015

Submitted by:

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- Dr. Subramanyam Bhadriraju – Kansas State University (Ethiopia project co-leader; Research/ Environmental Issues Coordinator)
- Dr. Andreia Bianchini-Huebner– University of Nebraska (Guatemala project co-leader; mycotoxin contamination prevention)
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- Dr. George Opit – Oklahoma State University (Ghana project co-leader; stored product insects and pests)
- Dr. Gordon Smith – Kansas State University (Bangladesh project co-leader; technology transfer)
- Dr. Shannon Washburn – Kansas State University (Engagement Coordinator)

The Feed the Future Reduction of Post-Harvest Loss Innovation Lab had active projects in five countries from October 1, 2014 to September 30, 2015

Afghanistan
Team Leaders: John F. Leslie (Kansas State University); Debra Frey (Kansas State University); Dr. Andreia Bianchini-Huebner (University of Nebraska-Lincoln)

Bangladesh
Team Leaders: Dr. Gordon Smith (Kansas State University); Dr. Prasanta Kalita (University of Illinois)

Ethiopia
Team Leaders: Dr. Subramanyam Bhadriraju (Kansas State University); Dr. Rizana Mahroof (South Carolina State University)

Ghana
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Guatemala
Team Leaders: Dr. Carlos Campabadal Teran (Kansas State University), Dr. Andreia Bianchini-Huebner (University of Nebraska-Lincoln)

Program Partners

Companies
Archer Daniels Midland Company (ADM) (Illinois, USA)
Agri Commercial Service Ltd. (Ghana)
GrainPro (Massachusetts, USA)
Hiwot Agricultural Mechanization P.L.C. (Ethiopia)
John Deere (USA)
Pens Food Bank Enterprise (Ghana)
Romer Labs (Austria)
Vestergaard Frandsen (Switzerland)
Woods End Labs (USA)

International Agencies
CGIAR International Center for Agricultural Research in the Dry Areas (ICARDA)
CGIAR International Maize and Wheat Improvement Center (CIMMYT)
United Nations Food and Agriculture Organization (FAO)

Universities
Bahir Dar University (Ethiopia)
Bangladesh Agriculture University (Bangladesh)
Fort Valley State University (USA)
Hawassa University (Ethiopia)
Kansas State University (USA)
Kwame Nkrumah University of Science and Technology (KNUST) (Ghana)
Mekelle University (Ethiopia)
Oklahoma State University (USA)
South Carolina State University (USA)
Universidad del Valle (Guatemala)
University of Energy and Natural Resources, Sunyani (Ghana)
University of Hohenheim (Germany)
University of Kentucky (USA)
University of Nebraska – Lincoln (USA)

Government Agencies
Ministry of Agriculture, Irrigation and Livestock (Afghanistan)
Savanna Agricultural Research Institute/Council for Scientific Research (Ghana)
US Agency for International Development (USAID)
USDA-ARS Center for Grain and Animal Health Research (USA)

Non-Profits
ADM Institute for the Prevention of Postharvest Loss at the University of Illinois (USA)
Compatible Technologies International (USA)
Partners in Food Solutions (USA)
Practical Action (Bangladesh)
SHARE Guatemala (Guatemala)

Acronyms

Africa RISING - Research in Sustainable Intensification for the Next Generation

BARC - Bangladesh Agricultural Research Council BARC

BARI - Bangladesh Agricultural Research Institute

BAU - Bangladesh Agricultural University

BD - Bangladesh

BRRI - Bangladesh Rice Research Institute

CFD - Computational Fluid Dynamics CFD)

DAE - Directorate of Agricultural Extension

EIAR – Ethiopian Institute of Agricultural Research

FGD - Focused Group Discussions

FtF – Feed the Future

GRAMAUS - Grameen Manobic Unnayan Sangstha

KNUST - Kwame Nkrumah University of Science and Technology KNUST

KSU – Kansas State University

MAIL – Ministry of Agriculture, Irrigation and Livestock

ME – Management Entity

MoFA – Ministry of Food and Agriculture

OSU – Oklahoma State University

PHL – Post-harvest loss

PHL IL- Feed the Future Reduction of Post-harvest Loss Innovation Lab

PICS - Purdue Improved Crop Storage

SAWBO - Scientific Animations Without Borders Organization

SBD – Solar Bubble Dryer

SPRING - Strengthening Partnership, Results, and Innovations in Nutrition Globally

STR – a low cost dryer made locally in Asia

UIUC – University of Illinois, Urbana, Champaign

USAID – U.S. Agency for International Development

USDA-ARS – United States Department of Agriculture –Agriculture Research Service

WEAI – Women Empowerment in Agriculture index

RH – Relative Humidity

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Feed the Future
Reduction of Post-Harvest Loss Innovation Lab

I. Executive Summary

The Feed the Future Reduction of Post-Harvest Loss Innovation Lab is a strategic and applied, research and education program aimed at improving food security by reducing post-harvest loss and food waste of seeds and durable staple crops, *e.g.*, grains, oilseeds, and legumes. The Lab's efforts are focused in four Feed the Future countries (Bangladesh, Ethiopia, Ghana, and Guatemala) and Afghanistan. Major goals/activities include:

- Increased understanding of current post-harvest task division in rural communities and households, and the development of technologies usable by all household members.
- Improve drying, handling, and storage technologies to reduce insect and fungal contaminants.
- Pilot test drying and storage technologies with low acquisition costs and limited operational footprints that are sustainably accessible to poor farmers.
- Develop creative animation tools that help even non-literate farmers understand the value of and implement technologies developed as part of the project.
- Develop a standard operational protocol that can be used to conduct baseline surveys of mycotoxin contamination in targeted agricultural products in multiple countries.
- Increase the quantity and quality of stored food staples to increase food safety and security for poor farmers.
- Develop strong partnerships with local NGOs to effectively spread information on the technologies developed to farmers throughout the targeted regions.

II. Program Activities and Highlights

- Installed Solar Bubble Dryers and developed at least one other drying technology in all four core countries.
- Began discussions with the USAID Mission in Honduras regarding a potential project buy-in to conduct a baseline survey of the mycotoxins present.
- Completed initial Gender Assessment studies and Focus Group Discussions in all countries.
- John Leslie replaced Director Dirk Maier and Managing Director Venkat Reddy. Anne Huss replaced Program Coordinator Roberta Hodges.
- Afghanistan – Established and staffed a functional mycotoxin detection laboratory and detected all of the mycotoxins being screened (aflatoxin, deoxynivalenol, ochratoxin, and T-2 toxin) in at least one of the tested foods (grapes, raisins, tree nuts and wheat).

- Bangladesh – Compared hermetic storage technologies with traditional storage practices, and began to scale-up and disseminate new storage technologies to farm households.
- Bangladesh – Evaluated SBD and STR dryers with rice from the 2015 Boro season.
- Ethiopia – Completed 2014 post-harvest loss assessments for chickpea, maize, sesame and wheat, and conducted modeling studies of dryer efficiency for multiple dryer designs.
- Ghana – Assessed the maize value chain in Northern Ghana through a face-to-face survey with farmers.
- Ghana – Identified ZeroFly® Storage Bags as the most effective in preventing new infestations by maize weevils, but as ineffective in reducing damage resulting from immature insects introduced into the bag along with the grain.
- Guatemala – Identified the drying and storage technologies currently in use in the region.
- Guatemala – Determined that maize from the highlands has aflatoxin and fumonisin at levels below international guidelines, but remain a safety concern because of the large amount of maize consumed by highland residents.

III. Key Accomplishments

- Enrolled 16 students (14 male and 2 female) in Master's (7) and Ph.D. (9) programs in either the United States (2) or in their home countries (14).
- Initial Focus Group Discussions were completed by the gender consultants in all four focus countries.
- Engagement Advisory Teams have been formed in all four core countries and have held initial meetings in Bangladesh and Ghana.
- Afghanistan – Obtained buy-in from USAID mission in Afghanistan to conduct a baseline mycotoxin survey, and to build institutional capacity in the Ministry for Agriculture, Irrigation and Livestock for continued screening of high value agricultural exports and dominant foodstuffs in Afghani diets.
- Bangladesh – Established the first functional mycotoxin detection laboratory in the country at Bangladesh Agricultural University.
- Bangladesh – Preliminary on-farm trials of GrainPro storage bags have generated significant interest in acquiring this technology by others in the villages where the bags have been used. There is particular interest in being able to store seed for the next season in these bags.
- Ethiopia – The use of unidentified pesticides sourced locally for grain storage is common and pose an unknown health risk to farmers who use them. Samples of these materials are now being analyzed and guidelines for their safe use will be developed.
- Ethiopia – Mekelle and Bahir Dar universities developed post-harvest technology curricula.
- Guatemala – The USAID mission has had maize from lowland regions in Guatemala (not Feed the Future regions) analyzed for quality. Grain from the lowlands is "imported" to the highlands later in the year as most farmers in the highlands do not grow enough maize of their own to be self-sustaining through the year and must purchase grain for household consumption for up to nine months of the year. This "imported" grain may be significantly contaminated with mycotoxins.

IV. Research Program Overview and Structure

The PHL Innovation Lab manages parallel projects in four core Feed the Future countries, *i.e*., Bangladesh, Ethiopia, Ghana, and Guatemala. Afghanistan was added as a mission buy in for a baseline mycotoxin analysis of dried fruits, tree nuts and wheat. Each country project is led by U.S. scientists representing the lead project organizations and an in-country counterpart from the primary subcontractor and collaborator.

Initial PHL Assessment – Surveys were conducted in each core country to understand the practical details and social context within each country. Baselines for storage, contamination and mycotoxin profiles have or soon will be established. The surveys identified multiple participants in the value-chain and that 80% of the household level processing is done by women.

Promising in-country, "on-the-shelf" and "in the field elsewhere" technologies/best practices are being evaluated through on-farm research with stakeholder participation. These technologies include **– storage** (Purdue Improved Crop Storage (PICS) bags; GrainPro Superbags/cocoons; hermetic metal drums/bins), **drying (**Hohenheim solar dryer), moisture measurement (USDA-ARS and John Deere moisture sensors), **mycotoxin assessment** (Romer Lab test strips), storability prediction (Woods End Lab CO_2 kits), **insect pest control** (diatomaceous earth dusts, silica nanoparticles, approved insecticides, and insecticide impregnated bags), and **market access** (USAID Warehouse Receipt Systems).

Projects focus on gaps identified in the initial PHL assessment, previous in-country experience, and input from USAID missions. In each country, there are three common research themes – mycotoxin contamination, storage, and drying. Projects in each country are led by Country Team Co-Leaders and overseen by the Lab's Director, with input from local and international academic, private sector, and governmental and non-governmental organizations.

Project Implementation – Projects in each country initially were confined to a select group of smallholder farms or storage facilities, and now are being expanded based on input from in country collaborators and USAID missions. Where possible, existing project sites being used by our in-country collaborators were chosen for project implementation.

A two-pronged approach is used for scale-up activities. An 'engagement strategy' moves results from pilot projects out for testing in broader geographic areas within the target country by targeting potential bottlenecks to wider adoption of new technologies. For example, education and training at the local village level was essential in West Africa for the success of the Purdue Improved Crop Storage (PICS) bags. This technology was adopted rapidly because it was readily available, inexpensive ($2 to $3 for 100 kg of grain capacity) and successfully reduced Bruchid infestation of cow peas. GrainPro bags with a zip closure cost approximately $1/bag if ordered in bulk. Before storing, grain must be properly dried to avoid fungal colonization and mycotoxin contamination. Mycotoxins can be easily quantified/monitored before and after drying, and the private sector in Ghana has helped to design and scale up these processes for maize in Ghana. Training local entrepreneurs to use and distribute handheld moisture meters and mycotoxin test strips should increase the adoption of these technologies. Minimizing grain moisture content as soon after harvest as possible is the most effective way to prevent mycotoxin synthesis during storage.

Inclusion of In-Country Private Sector and Other Organizations – Numerous, diverse organizations are assisting in scale up and outreach. Assistance provided to the Innovation Lab includes the time of academic faculty and staff to assist in project development, implementation and analysis, access to commercial and research facilities where pilot projects can be conducted, insights on cultural practices and preferences, contacts with in-country networks that enable on-farm experimentation and product/process training, evaluation, implementation, demonstration and adoption. PIs and country project team leaders are exploring, with USAID Mission staff, scale-up/expansion and funding of additional projects of local interest and to identify funding to encourage distribution and integration of the technology(ies) developed.

Cross-cutting Analyses – These analyses are part of each project.

Gender – Men and women participate differentially in post-harvest activities at the different locations. All four core countries have a local gender specialist who is assessing and documenting relative roles by gender in the villages where new technologies are to be piloted. Team members from each country participated in an all-day Gender Training Workshop at Kansas State University. Each country team also met separately with Dr. Cheryl O'Brien, a Gender Specialist from San Diego State University, to strengthen gender-sensitive approaches in their project activities.

Nutrition – Chronic malnutrition rates are high in all five host countries. We view improved nutritional outcomes from both food quantity and food quality perspectives. Better post-harvest management will increase the quantity and quality of grain available for consumption and/or sale, and improve nutrition by providing more calories for consumption or enabling the purchase of more diverse foods and reducing the acute and sub-acute mycotoxin toxicoses and related diseases. These toxins may stunt development in children under age 5, reduce immune system activity, and increase susceptibility to other diseases.

Environment – The proposed research programs and activities will adhere to USAID's Environmental Compliance Procedures in Title 22 of the Code of Federal Regulations, Part 216 (22 CFR 216). Most projects do not have a significant effect on the environment as they fall outside the 11 classes of action identified in Part 216.2 (d) (1). Portions of projects in Ethiopia and Ghana include the use of pesticides on commodities and in warehouses that must comply with procedures in Part 216.3. Wherever possible, all projects utilize renewable energy sources, *e.g.*, solar drying, and engage local artisans, business people and laborers to create and develop locally-produced tools and technologies.

Dissemination of technologies to small-scale farmers – Train-the-trainer programs will be established with US and host country PIs developing and training leadership teams, comprised of local stakeholders, in best technologies and practices. These groups will help develop the training programs for the larger groups. National symposia modeled on the 2012 Ghana Grains Council Pre-Harvest Networking event also will be developed. Subsequent village level training workshops will be reinforced by educational videos developed by UIUC's Scientific Animations Without Borders Organization (SAWBO).

V. Research Project Report

This section is organized on the basis of the country in which the work was done, and the three objectives common to all four countries – drying, storage, and mycotoxins. Collaborations, gender activities, and publications and presentations are summarized by country to avoid repetition, and then the activities for each objective within the countries are addressed. Capacity building is summarized in section VI.

Afghanistan

Collaborators:

Ministry of Agriculture Irrigation and Livestock (MAIL).

Bangladesh

Collaborators:

Bangladesh Agricultural Research Council (BARC), Bangladesh Agricultural University (BAU), Directorate of Agricultural Extension (DAE).

Gender:

Shahana Begum, a freelance consultant serves as the Gender Specialist and has conducted a gender equality assessment in eight villages of two sub-districts, Phulpur in Mymensingh and Monirampur in Jessore. The assessment includes questions on the role of women in post-harvest activities, the use of post-harvest technologies, and social and economic empowerment. In each village, three Focus Group Discussion groups of farmers were formed that were either segregated or mixed by sex. The discussion groups are complete in four villages in Phulpur and in all villages in Monirampur.

Ethiopia

Collaborators:

Bahir Dar University, Mekelle University, EIAR, Sesame Research Center at Humera.

Gender:

Mr. Solomon Petros from Mekelle University serves as the gender specialist, and is working directly with the Innovation Lab's in-country coordinator (Dr. Fetien Abay) to conduct a WEAI-informed survey and focus group discussions with men and women. For capacity building in country, ISSD (Integrated Seed Sector Development; a Netherlands Project) project staff and agricultural and research personnel have assisted in planning and conducting the focus group discussions. An initial regional workshop will be held in the first quarter of 2015 to determine WEAI.

Presentations and publications:

- *A pilot study using educational animations as a way to improve farmers' agricultural practices and health around Adama, Ethiopia.* J. Bello-Bravo, G. W. Olana., B. R. Pittendrigh. 2015. Information Technologies & International Development, 11, 23-37.
- *Enhancing food security in Ethiopia through reduction of postharvest losses and food wastes.* Subramanyam, Bh., Mahroof, R. M., Washburn, S., Reddy, P. V., Ambrose, K. R., Maier, D. Abstract published. 11th International Working Conference on Stored-Product Protection, December 23, 2014, Chiang Mai, Thailand.

Ghana

Collaborators:

Middle Belt – Ghana Grains Council, Pens Food Bank, Yedent Agro Group, Sahel Grains, Kwame Nkrumah University of Science and Technology (KNUST), local farmers and grain processors.

Northern Belt – The nine members of the Northern Ghana EAT Antika Co. Ltd., Masara N'Arziki Farmers' Association, Upper West MoFA Office, Northern Region MoFA Office, SPRING, Takhilla Farms Ltd.

Gender:

The Ghana project has not hired a gender consultant. Focus group discussions have been held in 10 communities in five maize-producing municipalities – Ejura-Sekyedumase, Tamale, Techniman, Wa and Wenchi. A workshop was held to validate focus group members' opinions and to sensitize women and Community opinion leaders about the need to empower women in post-harvest management. The workshop determined the extent of disempowerment by using a modified form of the Women Empowerment in Agriculture index and identified strategies to more effectively incorporate women into the project.

From the workshop, the following recommendations were made:

- The impact of the technologies on gender equity and women's empowerment should be tracked.
- All stakeholders in the Ghana project should be trained to identify, address and report gender imbalances observed during their field activities.
- The Ghana project should partner with Ghana Education Services to conduct training for women beneficiaries and empower women to transact business more efficiently as improved technologies are adopted.
- The Ghana project should hire a full-time Gender Specialist.

Presentations and publications:

- *Assessment of Maize Postharvest Losses in the Middle Belt of Ghana*, Opit, G. P., J. Campbell, F. Arthur, P. Armstrong, E. Osekre, S. Washburn, O. Baban, S. McNeill, G. Mbata, I. Ayobami, and P. V. Reddy. International Working Conference on Stored Product Protection, November 24, 2014, Chiang Mai, Thailand.
- *Curbing Maize Post-Harvest Losses in Ghana*, G. P. Opit., World Food Prize Event, October 15, 2014, Des Moines, Iowa, U.S.A.

Guatemala

Collaborators:

SHARE (local NGO), Universidad del Valle.

Presentation and publications:

- *Improving Food Security and Food Safety of Smallholders Farmers in the Western Highlands of Guatemala through Reduction on Post-Harvest Losses of Corn*, Carlos Campabadal, Andreia Bianchini, Jason Ellis, Luis Sabillon. International Working Conference on Stored Product Protection. November 26, 2014.

Drying Technology and Implementation

Bangladesh – Focus crop: Rice

Achievements: A low cost dryer (STR) design with potential application in Bangladesh was identified and its efficacy increased. This dryer has three basic components: a two-stage axial fan, an electric heater, and a bamboo-mat drying bin. The drying bin is very simple, can hold up to half a ton of grain, and is made from two bamboo mat fabricated cylinders. The moisture content of 300 kg of grain was reduced from 24% to 10% in 4 hours, an efficiency of 57.6%. The STR dryer's efficiency improved to 73.1% with a 400 kg grain lot. Controlling the heat source of this dryer is the most important variable during the drying process. The temperature throughout the length of the Solar Bubble Dryer (SBD) was uniform and heavily dependent on the amount of solar radiation/sunlight available. Drying time usually was 2-3 days and the grain moisture content was not always reduced to less than 12%.

Lessons learned: STR dryer performance was better than the SBD dryer. Problems with the SBD include the rake stirring mechanism, which was not effective and identifying a location for the dryer in the village, as the entire 25 m length of the dryer must be outside (theft and security problems) and placed to minimize shading.

Ethiopia – Focal crops: Maize, Wheat, Chickpea, and Sesame

Achievements: This project evaluated the performance of two solar dryers (SBD and Solar Cabinet by natural convection) by simulation and optimization, and compared these dryers with traditional open-air sun drying. Mekelle University was the lead for studies of chickpea and sesame, and Bahir Dar University was the lead for studies with maize and wheat. Weather data were the key model parameters for the dryers. The SBD was delivered and installed in June 2015. Current research includes modeling work to predict and optimize fluid flow, heat flow, and pressure drop inside the dryers using Computational Fluid Dynamics (CFD) software. Data loggers, thermocouples, moisture meters, and lux and anemometers were provided to Mekelle by the third week of August 2015.

Lessons learned: Rains have delayed the drying experiments, which began in mid-June and continued until September. Drying experiments will resume once the rainy season is over and as fresh material from the current year's harvest becomes available.

Ghana – Focus crop: Maize

Achievements: In June, U.S. Engineers travelled to Ghana to initiate solar drying-related experiments and to train colleagues at KNUST (Kumasi, Ghana) to set up, maintain and operate the Solar Bubble Dryer (SBD). KNUST M.Phil. students developed a protocol for evaluating the effectiveness of the SBD and a solar-biomass hybrid dryer. John Deere and PHL handheld moisture meters are being used to monitor and compare grain moisture before and after drying operations.

Lessons learned: Completely Randomized Design needs to be implemented to study the dryers in parallel, at the same location, and with same maize variety. The goals of this experiment were to assess the effectiveness of two dryers and to monitor parameters such as moisture, temperature, and RH of maize kernels. Effectiveness of the dryers should correlate with mycotoxin levels.

Guatemala – Focus crop: Maize

Achievements: The current local maize drying protocol is to dry maize in the field before harvesting. After harvest unshelled corn is dried in bags exposed to the sun, and in the attics of the farmer's house. Further drying of maize grain after shelling is rare. The following drying technologies will be tested for maize – a furnace-type dryer model (similar to the AflaStop shallow bed dryer), a solar bed dryer (similar to a solar bed dryer developed in India), and the STR dryer (developed in Vietnam). The STR dryer may be a usable technology, since even though fumes from the burner come into direct contact with the maize husk, as the smoking process does not alter palatability of the grain.

Lessons learned: Utilizing solar dryers in the Western Highlands in Huehuetenango is challenging due to the extensive cloud cover. The direct solar energy available in the area is less than in other Guatemalan locations. The SBD (GrainPro®) may be difficult to use due to its high capacity, complex setup, and the frequently cloudy weather.

Low-Cost Sustainable Grain Storage Technology

Bangladesh – Focus crop: Rice

Achievements: A survey of available rice storage technology from farmers who store their rice crops was completed. In the Jessore and Mymemsingh districts, 58% and 47% of the farmers, respectively, used traditional *Dole* storage and 11-17% include neem leaves (*Azadirachta indica*) as an anti-microbial agent. GrainPro® bags for rice storage were given to 40 farmers in these two districts. After four months of storage, four insect species were identified in traditional storage options at levels up to (~1 insect/gram of grain). No insects were found in grain stored in GrainPro® bags. Moisture levels (11.8% after drying) were unchanged in seed stored in GrainPro® bags, but increased by >2% in the *Dole* and *Motka* storage systems. Up to 6% of the grain stored in traditional storage structures was damaged after storage, but only 1% of the grain stored in the GrainPro® bags was damaged. Grain stored under laboratory and on-farm conditions in *Dole*, *Motka*, plastic drums and GrainPro® bags was evaluated for five months with similar results in terms of infestation and grain quality in both laboratory and field studies. GrainPro® bags were superior to the other three tested storage methods.

Lessons Learned: GrainPro® bags were superior to *Dole, Motka* and plastic drum storage, which varied in efficacy depending upon the data attribute measured. About 60% of farmers store their own harvest at the farm level.

Ethiopia – Focal crops: Maize, Wheat, Chickpea, and Sesame

Achievements: At Mekelle University about 600 kg each of chickpea (initial temperature 23.5ºC, moisture content 8.2%, and 0.5% dockage) and sesame (initial temperature of 35.3ºC, moisture content 4.9%, and 1.4% dockage) were procured from the Amhara and Tigray regions. Storage bags tested were: PICS triple bags, GrainPro®, polypropylene bags, and jute bags. The latter two bags traditionally are used to store sesame and the first two are improved storage bags that will hold ~10 kg of grain each. For sesame, after the first month of storage, no insects were observed in any of the bags. For chickpea, the baseline infestation was 1, 24, 0, 8, and 22 adult beetles (Bruchids) for PICS triple bags, GrainPro®, polypropylene bags, and jute bags, respectively, and were not significantly different after one month of storage. Thirty sesame farmers in Humera and 30 chickpea farmers in Gondor were identified for on-farm studies. A pitfall trap with food-baited oil and a sticky trap with multiple pheromone lures were placed in each farmer's storage area. Five pitfall and five sticky traps were placed in each of ten sesame warehouses. On-farm traps are checked every six weeks for eight months for sesame and for six months for chickpeas.

At Bahir Dar University (maize and wheat), the storage options included metal bins, plastic drums, Superbags, PICS bags, polypropylene bags, and jute bags. None of the samples were treated with an insecticide. Maize stored for 10 months in polypropylene and jute bags had the highest weevil infestation levels

and the, most grain damage. Wheat stored for nine months exhibited similar trends. Of 30 farmers surveyed, 14 stored maize in *gota* (traditional mud plaster), 7 in *gotera* (traditional wooden structure), and 9 in fertilizer bags. Six farmers treated the maize with pirimiphos-methyl (Actellic dust), an organophosphate. In the April 2015 visit, maize weevils (1-34 beetles/kg sample) and Angoumois grain moths (2-80 moths/kg) were found. Six weeks later there were 1-768 beetles/kg and 3-191 moths/kg. In the June 2015 visit, samples were evaluated from 30 farmers with maize crops up to 2 years old that were stored primarily in *gota* but with a few in polypropylene bags or drums. Twenty-five of thirty farmers used malathion dust, diazinone, phosphine fumigation or pirimiphos-methyl. In all cases, the number of beetles and moths increased significantly after 6 weeks of incubation.
Lessons learned: Lack of timely funding created problems in paying for a vehicle for field site visits. Stored-product laboratories at Bahir Dar and Mekelle Universities had to be equipped to conduct the research before the insects could be extracted from samples. Lack of ability to identify insects to species level was a major challenge, and opportunities for training in this area must be identified for staff to function independently of the US PIs. The university laboratories still lack growth chambers and are not equipped to conduct experiments in which grain in different storage bags is challenged with insects. The percent damaged kernels and number of live beetles (weevils) were significantly higher in chickpea than in sesame. Most farmers currently are using traditional storage methods and treating their grain with an insecticide that may not be registered for such purposes and appear to be ineffective. Probe type traps were the most efficient traps for maize weevils and grain moths, but phermone or sticky traps were needed to catch Indian meal moths. For wheat, Indian meal moths dominated in samples from both warehouse facilities and small storage structures, although weevils were found in significant amounts in the storage structures.

Ghana – Focus crop: Maize

Achievements: An assessment of the effectiveness of the ZeroFly® Storage Bag is in progress in three major maize growing areas. Warehouses (sites) selected for the experiments are either near maize storage areas or near market areas that have high insect pressure. Three treatments were used: 1) Betallic-treated maize in untreated polypropylene (PP) bags; 2) Untreated maize in untreated PP bags, and 3) Untreated maize in deltamethrin (DM) treated polypropylene (PP) bags [ZeroFly® Storage Bags]. ZeroFly® Storage Bags were obtained from Vestergaard's local stock, and untreated polypropylene bags, Betallic Super EC, and mouse traps were obtained from a local market in Ejura. Stored-product insect pest populations were significantly lower than the untreated control during the first 5 months of maize storage in the ZeroFly® bags. However, the number of maize weevils increased markedly in ZeroFly® bags after three months of storage' probablt due to immature stages of insects surviving pre-experiment phosphine fumigation thereby highlighting the need to put insect-free grain in ZeroFly® bags.

A KNUST team visited the USA for a month of stored-product insect pest management training. The visitors gained knowledge on methods in stored-product insect pest management research (experimental design, data collection, and data analyses) and writing scientific reports. Through guided tours, the visitors became familiar with current grain storage and processing methods used in the United States.
Lessons learned: It was difficult to get permission to conduct experiments in storehouses or warehouses near the maize markets in Ejura, Techiman, and Wenchi. Training the Ghana-based members of the team on some of the experimental procedures for data collection prior to the commencement of the ZeroFly® bag field experiment was difficult and occurred only when PIs from the U.S. traveled to Ghana.

Guatemala – Focus crop: Maize

Achievements: A survey was conducted of 272 families (small holder farmers) in 14 communities that grow or purchase maize for self-consumption and found that: 1) Maize was the main source for carbohydrates for subsistence farmers in Huehuetenango. 2) Most farmers do not control enough land to produce all of the maize their family consumes in a year and must buy maize from the lowlands of Guatemala or from southern Mexico. 3) An average farmer will harvest 400-460 kg of maize/year, which normally suffices for 3-4 months for a family of 5 to 6 individuals. 4) The average household loses ~10% of the annual maize produced to mold, rodents, birds, insects, and diseases. 5) Visual, sound, and touch-based methods

of grain quality evaluation are used for maize. 6) Shelled maize is stored primarily in bags (81%), and much less commonly in metal silos (10%), boxes (7%), and barrels (2%). Storage technologies to be evaluated include: GrainPro® Super Bags, PICS bags, locally produced plastic storage bags, optimized bulk storage bins (metal silos and boxes), and attic modifications.
Lessons learned: Current postharvest practices are not effective in reducing post-harvest losses. The farmers usually are reluctant to accept new technologies. There is very little knowledge of the health problems caused by the fungi and mycotoxins present in maize. Women and children are not heavily involved in maize harvest practices, but have a major role in housework. Visual observations of maize stored in attics, metal silos and bags found very limited infestation by stored product insect pests.

Mycotoxins and Fungal Contamination

Afghanistan – Focal crops: Grapes/raisins, Tree nuts, Wheat

Achievements: This project has a short projected life span of somewhat less than one year. A functional mycotoxin laboratory is now in place and raisins, walnuts, almonds, pistachios and wheat are being tested for the presence of one or more of: aflatoxin, ochratoxin, deoxynivalenol (also known as DON and vomitoxin), and T-2 toxin. Contamination in raisins and tree nuts is important because of international trade regulations that limit toxin contamination in these commodities. Wheat contamination is important because it is the largest single component of most Afghani's diets (500-600 g/day). The effects of any toxins present in wheat will be magnified because of the high level of this grain in the daily diet. Testing of samples from various portions of the country are in progress, with all toxins present at significant levels in at least some of the samples tested to date.
Lessons learned: The logistics for this type of work in Afghanistan is difficult due to the security situation. Testing imported wheat is a significant issue that requires training of appropriate border control personnel. Proving that toxins are at least a contributing factor to existing health problems will require monitoring biomarkers for toxin exposure within the potentially affected populations, as overt symptoms of mycotoxin toxicoses may be due to multiple causes.

Bangladesh – Focus crop: Rice

Achievements: Moisture was the key parameter for assessing rice quality. Three moisture meters – John Deere, an inexpensive local meter, and the INDOSAW standard – were compared. Price, detection speed, and portability are the critical characteristics of these meters. The readings from the John Deere moisture meter were, on average, 2% higher than those from the INDOSAW meters. A survey of 200 farm households found there was little or no knowledge of the problems and health risks associated with mycotoxin contamination. Fungi linked to mycotoxin formation often discolor grain surfaces. Based on visual inspection, 18% of the 2015 Boro season samples with moisture content >20% were moldy, while only 4% of samples with the moisture content <12% were moldy. In blotter tests for viable fungi, 19% of the tested grain carried viable *Aspergillus* inoculum and 9% carried viable *Fusarium* inoculum. Samples with high levels of viable fungi (> 10% infected grains) are being evaluated for aflatoxins and fumonisins by using Romer Lab test kits. The number of rice moths and rice weevils was correlated with fungal contamination and was higher in samples with high moisture content. In samples with moisture content >18% (indicating greater mold presence), 38% of the seeds germinated, while in samples with moisture content <12% (indicating lesser mold presence), 94% of the seeds germinated.
Lessons Learned: Insects can move mold spores within and between grain lots, increasing contamination issues. Fungal contamination is associated with seed germination failure, and only seed with moisture content < 12% should be saved for use as seed during the coming season. Samples evaluated were taken directly from the field and had not been stored, so fungal contamination is initiated in the field. Identification of some *Aspergillus* and *Fusarium* isolates to species will increase the predictability of toxins that could be present on the grain.

Ethiopia – Focal crops: Maize, Wheat, Chickpea, and Sesame

Achievements: For chickpea, aflatoxins were found at levels from < 2 to 100 ppb. Fumonisin and DON were present at < 5.1 ppm for all types of storage, including PICS bags, GrainPro® Super bags, jute bags, polypropylene bags, and metal bins. In sesame, aflatoxins were detected in 9/30 samples (range from < 2 to 87 ppb). In wheat, fumonisins were < 0.5 ppm for all samples tested. All wheat samples contained detectable aflatoxins (range from < 2 to 29 ppb), with the toxin levels tending to increase with storage time.
Lessons learned: All of the results are from just the first month of sampling. Maize is expected to have the most problems with mycotoxin contamination. As expected, toxin levels are correlated with grain moisture content, insect infestation, temperature, and grain age.

Ghana – Focus crop: Maize

Achievements: MOUs with Africa RISING (Research in Sustainable Intensification for the Next Generation) and SPRING (Strengthening Partnership, Results, and Innovations in Nutrition Globally) have been signed. These MOUs will enable baseline measurements of aflatoxin levels in the Northern and Middle Belts of Ghana, and the conduct of collaborative experiments looking at the relationship between toxin contamination and insect infestation.
Lessons learned: None yet. Baseline assessments began in July 2015.

Guatemala – Focus crop: Maize

Achievements: Identification has begun of the fungi and mycotoxins present in maize from smallholder farmers in Chiantla and Todos los Santos. Samples were analyzed at UVG with a Romer Labs mycotoxin analysis kit after 0, 30, 60 and 90 days of storage. Maximum aflatoxin contamination was 18 ppb and averaged 7.9 ppb. Maximum fumonisin contamination was 31 ppm and averaged 3.4 ppm. Neither aflatoxin nor fumonisin levels increased in these samples during storage. Fungi belonging to the genera *Aspergillus*, *Fusarium*, *Penicillium*, *Verticillium*, and *Cladosporium* were identified in the samples, and the total mold count was usually ~ 10^5 CFU/g. Stored product insects were uncommon in the samples.
Lessons learned: The number of samples analyzed is limited to 70 per season by cost. Probable causes for reduced insect infestation include the low ambient temperature (17°C), storage of the maize on the cob in the husk, and the smoke used to dry much of the grain stored in the attics of the farmers' houses. Such conditions also would reduce fungal growth.

VI. Human and Institutional Capacity Development

a. Short term Training

Country	Number (sex disaggregated)	Purpose	Home Institution/ Place of training	Training Mechanism
Bangladesh	12 (F), 12 (M) farmers 6 (M) Private sector 6 (F), 74 (M) Govt. off 2 (M) students	Storage trails, tracking mycotoxins, use for moisture meters. Students helped set up the dryers and participated in their operations.	BAU	FGDs, seminars, workshops, hands on training individual basis. Annual training workshop
Ghana	2 (M) faculty; 2 (F), 3(M) students 1(F), 1(M) students; 1(M) local entrepreneur	Aflatoxin, solar dryer set up and training, handheld moisture meter training. Visited U.S. for post-harvest storage workshop for 1 month	KNUST OSU	Workshops, seminars, informal training.
Ethiopia	1(F), 2(M) students 4 (M) students	Conducting trials and workshops on insect identification, mold, and drying	Bahir Dar University Mekelle University	Workshops, hands on training, informal sessions, participation in research trials.
Guatemala	1(F), 2(M) students 5(F), 1(M) students	Designing dryers as part of their senior design project Mold identification workshop (one day), moisture content meter training	SHARE Guatemala, Universidad del Valle	Workshops, hands on training, participation.
Afghanistan	2(F), 12 (M) MAIL technical staff	How to collect samples, extract them and run mycotoxin assays	MAIL	Workshops, hands on-training, several months of on-the-job training

*M = Male, F= Female

b. **Long term Training**

Support for graduate education is an important part of PHLIL's mission to build capacity for the next generation of post-harvest experts. Graduate students are also essential in performing PHLIL's activities, including lab and on-farm research and assisting in PHL trainings. In Bangladesh, PHLIL is supporting five graduate students at Bangladesh Agricultural University. The students are working on doctoral degrees in our three key areas of drying, storage or mycotoxin analysis. There are nine graduate students involved with our programs in Ethiopia, eight at Mekelle and Bahir Dar universities and one at Kansas State University. In Ghana, two graduate students from Kwame Nkrumah University of Science and Technology (KNUST) are involved in PHLIL activities. In Guatemala one graduate student at the University of Nebraska-Lincoln is engaging in PHLIL research and training, with support from USDA.

Institutional Development

Afghanistan

Partner: Ministry of Agriculture, Irrigation and Livestock
Description: Remodeled and refurbished space into a functional mycotoxin testing laboratory with separate locations for extracting samples and running tests. Provided readers and all other supplies, equipment and SOPs to conduct mycotoxin assessments. Trained local MAIL staff to sample field and storage facilities and to run Romer Co. test kits for mycotoxin contamination in tree nuts, grapes/raisins and wheat.

Bangladesh

Partner: Bangladesh Agricultural University (BAU).
Description: Installation of two types of dryers; provision of sufficient hand held moisture meters, including John Deere, PHL meters, and a commercial Indian brand, to conduct drying and storage trials. Romer Lab test kits were delivered to BAU for assessing mycotoxin contamination levels. To our knowledge this is the first functional mycotoxin testing lab in the country. Full day hands on workshop led by Drs. Leslie and Smith on summarizing technical data for non-peer audiences. Planning for engagement/outreach activities, including: active learning, curriculum development, assessment, use of multi-media tools, and gender inclusion strategies.

Ethiopia

Partners: Mekelle University and Bahir Dar University.
Description: Equipped mycology laboratories at Mekelle and Bahir Dar Universities with ELISA readers and test kits for mycotoxin analysis – aflatoxins, deoxynivalenol and fumonisins (at both universities), and ochratoxin (only at Mekelle). A GrainPro® Bubble dryer was delivered to and installed at each university. Nineteen HOBO data loggers with temperature and humidity measurement capability, 27 Button sensors, several USDA moisture sensors, and 3 John Deere moisture meters were provided for each university. The following insect sampling equipment was provided to each university: pitfall traps, sticky traps, lures, vials for collecting insects, brushes, forceps, and sieves. Kansas State University should continue to support both universities by purchasing test kits for mycotoxin research, and offering training in laboratory techniques for extracting and quantifying molds and mycotoxins.

Ghana

Partner: Kwame Nkrumah University of Science and Technology (KNUST).
Description: A U.S. team travelled to Ghana from February 27 to March 15, 2015 to oversee the set-up of experiments and provide low cost moisture meters developed by USDA. From June 12-19, 2015, a U.S. team travelled to Ghana to initiate solar drying-related experiments and to train collaborators at Kwame

Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana in setting up and operating the GrainPro® solar bubble dryer, grain sampling and handling protocols, and the use of aflatoxin testing kits.

Guatemala

Partners: SHARE Guatemala (a local NGO), Universidad del Valle.
Description: Mycotoxin testing laboratories at Universidad del Valle were set up by a U.S. scientist. Fungal identification workshops and seminars will strengthen the background of relevant university faculty and staff in this area. Solar dryers were set up at the university where undergraduate students are helping to design and build them as a part of their senior year project.

VII. Technology Transfer and Scaling Partnership (if applicable)

Bangladesh

Project Advisory Teams

The heads of partner institutions engaged in post-harvest loss reduction activities for rice nominated members of an Engagement Advisory team. Members have agreed to serve, but have yet to meet. Committee members include:

Professor Dr. Md. Monjurul Alam, PHLIL BD (Chair)
Dr. Sultan Ahmmed, Bangladesh Agricultural Research Council (BARC)
Mr. Ashfaq Ahmed, PHLIL BD (Secretary)
Dr. Mohammad Abdur Rahman, Bangladesh Rice Research Institute (BRRI)
Dr. Md. Ayub Hossain, Bangladesh Agricultural Research Institute (BARI)
Mr. Sk. Md. Nazim Uddin, Directorate of Agricultural Extension (DAE)
Professor Dr. Mahfuza Begum, Bangladesh Agricultural University (BAU)
Professor Dr. ShahnajParveen, Bangladesh Agricultural University (BAU)
Md. Hasan Aref, Jagorani Chakra Foundation
Md. Abdul Khaleque, Grameen Manobic Unnayan Sangstha (GRAMAUS)
Nikhil Biswas, Lead farmer (Jessore)
Md. Akikul Islam, Lead farmer (Mymensingh)
Rochona Mollik, Woman farmer (Jessore)
Ruma Sultana, Woman farmer (Mymensingh)

Technologies transferred and scale

Two pilot scale solar dryers are installed and functional at BAU.

Ethiopia

Project Advisory Teams

General information gathering meetings during the first and second project years enabled the project team to identify eleven key stakeholders who now serve on the Engagement Advisory Committee and who collectively represent the public and private sectors, and governmental and non-governmental organizations. The EAT met first in July, 2015 where they will utilized results of the surveys conducted during Project Year 1 to formulate key concepts for training curriculum development and to identify key training messages. They also discussed plans for recruiting trainers and targeting stakeholder training participant organizations.

Technologies transferred and scale

Scripts have been finalized for one of the two SAWBO training videos targeted for development in project year two and a second script has been drafted. These training videos address best management practices for use of phosphine fumigants for insect control in stored grain and the use of solar dryers for grain drying. Animation work for both videos has begun and audio recording of finalized scripts in local dialects will begin in Project Year 3. These videos are targeted for the general rural population in Ethiopia. Two pilot scale solar dryers were installed at Bahir Dar and Mekelle Universities. Cabinet dryers at both locations have been rehabilitated.

Ghana

Project Advisory Teams

Engagement Advisory Teams (EATs) for both Northern Ghana and the Middle Belt have been formed. The EAT for the Middle Belt has 10 members and the EAT for Northern Ghana has 9 members. An eight member Technology Research Implementation Team for the entire project also was established. MoUs with AFRICA RISING and SPRING, who are key partners for distribution of improved technologies, have been signed with Oklahoma State University.

The 10 members of the Middle Belt EAT are:

- Mr. Sam Okang-Boye (Ghana Grains Council)
- Mr. Maxwell Adu (Pens Food Bank)
- Mr. Evans Nsiah (Pens Food Bank)
- Mr. Kenneth Afo Osei Atiemo (Yedent Agro Group)
- Mr. Kwame Boateng (Sahel Grains)
- Mr. Benson Acheampong (Farmer)
- Dr. J.A. Bakang (KNUST)
- Ms. Beatrice Acheampong (Farmer)
- Mr. Kwame Ahiadu McLawrence (MoFA Nkoranza)
- Mr. Yew Opoku (Grain Processor)

The nine members of the Northern Ghana EAT are:

- Mr. Antiku Abdulai (Antika Co. Ltd.)
- Ms. Matilda Exornam (Masara N’Arziki Farmers Association)
- Mr. Huudu Abu (Upper West MoFA Office)
- Ms. Elizabeth (Upper West MoFA Office)
- Prince Fuseini Haruna (Northern Region MoFA Office)
- Mr. Dokurugu Salifu Ziba (SPRING)
- Chief Kuri B Limann (Takhilla Farms Ltd.)
- Mr. Musah Alhassan (Gundaa Produce)
- Mr. Musa Salifu Taylor (Agriculture Technology Transfer project)

The eight members of the Technology Research Implementation (TRI) Team for Ghana are:

- Prof. Ebenezer O. Owusu (University of Ghana)
- Prof. R. T. Awuah (KNUST)
- Dr. Joseph Ofei Darko (KNUST)
- Dr. Joseph Atehnkeng (Africa RISING)
- Dr. Abdulai Mumuni (Savanna Agricultural Research Institute)
- Prof. Daniel Obeng Ofori (University of Energy and Natural Resources)
- Mr. Evans Nsiah (Pens Food Bank Ent.)
- Mr. Kwame Boateng (Sahel Grains)

Technologies transferred and scale

Two pilot scale solar dryers were installed at KNUST. Further scale up of drying experiments is planned for Project Year 3.

Guatemala

Project Advisory Teams

MoUs with SHARE and Universidad del Valle remain active. These agreements add to facility and capacity of the local NGO and university through the cross exchange of technologies, training, and research results. Members of an Engagement Advisory Team have been identified, but not all have agreed to serve.

Technologies transferred and scale

Pilot scale solar dryers installed at Universidad del Valle are being redesigned and improved by students who participate in their operation.

VIII. Environmental Management and Mitigation Plan (EMMP)

Most research activities do not have a significant effect on the environment as they fall outside the 11 classes of action identified in Part 216.2 (d) (1). However, the projects in Ethiopia and Ghana, which include the use of pesticides on commodities and in warehouses, must comply with procedures set forth in Part 216.3. Whenever the project plan of work includes the evaluation of insecticides (Ethiopia) or insecticide-treated bags (Ghana) in large field trials and multiple locations, Pesticide Procedures (22 CFR 216.3) were implemented and no violations have been reported so far. Dr. Bhadriraju developed an approved Environmental Mitigation and Monitoring Program (EMMP) in 2014, that will be updated in the coming year to include methods to dispose of mycotoxin-contaminated grain and waste from mycotoxin tests. As new pesticides are tested, the EMMP will be updated again.

IX. Open Data Management Plan

The Management Entity (ME) will make information and data publicly accessible on the Innovation Lab's website and will develop a data sharing policy for primary investigators and research teams that will address access and timelines. The ME will abide by all the data sharing policies and procedures set by Kansas State University, USAID, and the other partnering institutions. In addition, a web-based data collection interface (Piestar) supports internal data collection with respect to project milestones, reports, budgets and financial expenditure. The general data management plan is as follows:

A. **Data Description:** Includes Work Plans, PMPs, Annual Reports, and Repository of documents for USAID. In addition, the ME collects individual country meeting and trip reports, along with site visit reports and reports on in-country meetings held to consider strengths, weaknesses, opportunities, research priorities, and outputs. All financial data and data generated from research projects are collected and archived by the ME.
B. **Data Organization and Management:** A local data management company, Piestar, developed a web-based Monitoring, Evaluation, and Progress Reporting System (MEPRS). This system is customizable, accurate, reliable, user-friendly, and supported by secure internet connections. A major benefit derived from this system is the ability to use components already available to other USAID Feed the Future Innovation Labs based at Kansas State University. Excel and Word files generated by the ME are stored in external hard drives at K-State available (locked with user permission) only to authorized users within the Dean of Agriculture's office.
C. **Data Access and Sharing:** The ME abides by the data sharing policies and procedures established by Kansas State University, as well as other partner institutions. The ME bears the overall responsibility for data management over the life of the project and will monitor and supervise compliance throughout the life of the project. Data will be preserved and made available over generational shifts in technology to ensure that it remains accessible over time.

Policies: Training and regulations potentially required of or applicable to researchers participating in this project by the Research Compliance Office at Kansas State University include:

- *Human Subjects Research Institutional Review Board (IRB)*. The IRB administers a comprehensive and compliant Research with Human Subjects program for researchers, students, and potential human subjects. At Kansas State University the Committee on Research Involving Human Subjects serves as the IRB and exercises oversight of all activities involving research with human subjects.
- *Responsible Conduct of Research (RCR)* training is an individual and an institutional requirement. All persons involved in research activities must have a working understanding of the responsible conduct of research to make the best ethical and legal choices in the face of potential conflicts involving research activities. This training develops an appreciation for the range of accepted scientific practices for conducting research, and the need to be knowledgeable about the regulations, policies, statutes, and guidelines that govern the conduct of University-sanctioned research.
- *Confidential/Sensitive Research (C/SRC)*: C/SRC policies govern activity(ies) proposed by Kansas State university faculty and staff that involves information for which general access to or distribution of should be restricted, or is inadvisable, illegal, or contraindicated.
- Project staff will adhere to all federal laws and regulations for oversight of activities involving research with human subjects and will analyze, present, and communicate the results of such studies in a manner that preserves participant confidentiality and accurately portrays their views. Project staff will file the appropriate paperwork with the Institutional Review Board (IRB) at K-State. All of Kansas State Universities' human subject's studies, regardless of funding source, are guided by the ethical principles in *The Belmont Report: Ethical Principles and Guidelines for the Protection of Human Subjects of Research* and the *National Commission for the Protection of Human Subjects of Biomedical and Behavioral Research*.

Status Update (Year 2): The Piestar website is fully active and serving as a depository for all reports, plans, trip summaries, and other research outcomes. Additional data stored on Kansas State University servers follows the University's Policies and Standards.

X. Project Management Activities

Management Entity staff at Kansas State University have changed significantly. Dr. Dirk Maier (Director) and Dr. Venkat Reddy (Managing Director) left Kansas State University in August 2015, and have been replaced by Dr. John Leslie as the Interim Director on a 50% basis. Ms. Roberta Hodges (Program Coordinator) left the position in July 2015 and was replaced by Dr. Anne Huss on an Interim basis. Dr. Huss's term as Interim Program Coordinator will end in early October as her replacement has been identified but has not yet come on board. A national/international search for a permanent replacement for Dr. Leslie (100% time) is in progress with a target start date for this individual in the first half of 2016.

The in-country institution responsible for performance of the Bangladesh project shifted from IRRI to Bangladesh Agricultural University in January 2015.

Dr. Mary Meck Higgins (Kansas State University), the Lab's Nutrition consultant, has retired and been replaced with Dr. Brian Lindshield (Kansas State University). Dr. Lindshield expects to conduct surveys to determine the impact of improved post-harvest technologies on the nutrition of families in the targeted villages in the four core countries.

Dr. Gordon Smith (Kansas State University) has replaced Dr. Reddy as co-PI for the Bangladesh project in collaboration with co-PI Dr. Prasanta Kalita (University of Illinois). An operations budget for Dr. Smith remains to be established.

Dr. Cheryl O'Brien (San Diego State University) is working as a consultant with Dr. Nina Lilja (Kansas State University) to manage the gender activities in the project.

Dr. Leslie has replaced Dr. Maier as P.I. for the Afghanistan project.

XI. Other Topics

Nothing to report.

XII. Issues and How They Are Being Addressed

Timing of field experiments: Timing for field experiments remains a challenge. In some locations, the rainy season hindered installation and operation of the solar dryers. In others, delays in the transfer of funds or the receipt of essential supplies and equipment resulted in missing a critical portion of a field season. Experimental plans have been altered to make up the planned research, and to ensure that necessary materials and supplies are available for the experiments planned for Year 3.

Ethiopia – Supply and Equipment Availability and Capacity Building: A major challenge at both universities in Ethiopia is obtaining basic reagents and materials in a timely manner. The universities both have a competitive bidding process that requires an inordinate amount of time. Restructuring this process has been recommended to appropriate university administrators.

The AgraVision reader at Mekelle University became non-functional in February of 2015. The repaired reader was returned to Ethiopia in July 2015, along with an ochratoxin reader and additional test kits to replace those that had expired while the reader was not functional.

Ethiopia – Grain Storage Pesticides: In Ethiopia, farmers use toxic pesticides available from local stores. The pesticides are sold in small vials but the chemicals present in the vials are unknown, and there are no guidelines for their safe use. Bahir Dar University has an analytical laboratory. Samples collected from farmers and warehouses will be tested for pesticide residues, and local pesticides sold to farmers for grain treatment evaluated to identify the active compounds. Previously uncharacterized compounds will be considered for laboratory trials to determine the efficacy of these products on stored-product insects.

Management and Funding of the Bangladesh Project: The Bangladesh budget currently is funded completely through the ADM Institute at the University of Illinois. Initially the project was managed by a faculty member at the University of Illinois who received operational support directly from ADMI, served as a co-PI with Dr. Prasanta Kalita and worked with Dr. Al Schmidley of IRRI who was based in Bangladesh. During this project year, the Illinois co-PI left the project and was replaced by Dr. Venkat Reddy, the Innovation Lab's Managing director. While co-PI, Dr. Reddy used the project's core budget to support his efforts in Bangladesh – travel, supplies, equipment, etc. With Dr. Reddy's departure in August, identification of another co-PI for the Bangladesh project was essential. Dr. Gordon Smith of the Grain Science and Industry Department at Kansas State University has agreed to assume this role and traveled to Bangladesh in August 2015. There is no operational budget for the Bangladesh project in the portion of the Innovation Lab budget administered at K-State. Arrangements need to be made with the University of Illinois to fund operations for Dr. Smith in his role as co-PI, so that his operations are not funded from the Lab's core budget, which is meant to benefit all of the projects supported by the Innovation Lab.

Innovation Lab Leadership: Leadership in numerous portions of the lab changed during this Project Year. Changes in leadership of the Nutrition program and the Bangladesh program are positive developments and bring new thoughts, insight and leadership to these components of the program. The transition with ME staff has been rough as all of the ME staff other than the half-time accountant will be new by early 2016. Dr. Leslie brings strengths in mycotoxin research that have increased the Lab's credibility in this important area. His availability to the program once his time as Interim is complete will be an important factor in maintaining this credibility. K-State currently is recruiting a permanent replacement for Dr. Leslie. Should that search fail, then the structure of the ME may revert to its previous form of full-time Associate Director and part-time Director, with Dr. Leslie retaining the part-time Director position. Clearly there will be some instability within the ME for most, if not all of the coming year.

XIII. Future Directions

- Gender reports in combination with the surveys completed in Plan Year 1 are providing important insights into local culture-dependent norms and divisions of labor that extend beyond just the management of post-harvest problems. Keeping these various patterns of the division of labor in mind when developing and transferring technologies will be essential for their eventual sustainable adoption.
- Multiple options exist for suitable drying and storage solutions, and no one solution is likely to be the "right" one for all countries, or perhaps even for all of the communities within a country. Developing a portfolio of potential technologies from which the best technology for a given situation can be selected is essential for sustainable change in both storing and drying grain.
- Identifying local suppliers and manufacturers of dryers and storage materials and partnering with them to ensure high quality products are put on the market remains a target in all four core countries.
- The mycotoxin component of the portfolio has developed a "blueprint" that can be used in many countries to conduct a baseline survey. Using this blueprint to solicit funding from other USAID missions would increase the number of countries in which the Lab is involved as well as providing baseline data from which decisions about needed remediation approaches, if any, could be made. The Lab is well-positioned to both lead and to partner with others in designing and implementing studies to reduce mycotoxin severity from on-farm plant production to post-harvest storage, sales, marketing and regulation.

Appendix A. Success stories

Solar Bubble Dryers

Using the sun's rays to dry grains by spreading grain on the ground or other hard surface for days at a time is a time honored means of drying grain to help preserve it. Unfortunately such grain can easily be eaten by rodents and other pests, colonized by fungi and insects, and rewetted if an unexpected shower occurs. The Feed the Future Reduction of Post Harvest Loss Innovation Lab is working in four countries with a Solar Bubble Dryer manufacturer by our GrainPro partner to both speed the drying process and overcome known problems that enable grain quality degradation and colonization by fungi and insects. The Solar Bubble Dryer is 25 m in length and 1 m in width. It has a clear polyethylene top and a bottom of a proprietary watertight material that keeps grain from coming into contact with the ground. It unzips when being loaded with grain or when the grain is raked to help ensure good mixing and uniform exposure to the heated air at the surface. Air is circulated through the grain by using a small fan powered by a solar cell. The dryer can be used under any weather conditions and installed in open fields or on rooftops. On a clear day the additional solar heat and air circulation lead to drying occurring more quickly than occurs with seeds spread on a more traditional hard surface, and the lack of contact with the ground reduces insect and microbial colonization. Testing of these dryers under very different conditions in Guatemala, Ghana, Ethiopia and Bangladesh is helping identify the best locations for using this conceptually old but functionally high-tech dryer to benefit some of the world's poorest farmers.

Figure 1. Traditional drying of maize grain in Ghana. The grain here is spread on a tarp on the ground and mixed by women walking through the grain to turn it and thereby hasten the drying process.

Figure 2. Members of the Feed the Future Reduction of Post-Harvest Innovation Lab Team installing a Solar Bubble Dryer in Ethiopia.

Mycotoxin Survey in Afghanistan

War-torn Afghanistan used to export high quality grapes, raisins, dried fruits and tree nuts to international markets in Asia, Europe and the Americas. Recently these high-value agricultural products have been rejected by many receiving countries because the levels of various toxins produced by fungi, also known as mycotoxins, are too high to meet international phytosanitary requirements. In addition, many Afghanis suffer from health problems that might be attributable to chronic exposure to sub-acute levels of mycotoxins. The best source for subacute mycotoxin exposure is a foodstuff that dominates in the diet. In Afghanistan this foodstuff is wheat, with most Afghanis average wheat consumption topping 500 g per day. The Feed the Future Reduction of Post-Harvest Loss Innovation Lab has trained staff employed by the Afghanistan Ministry of Agriculture, Irrigation and Livestock in methods to collect agricultural samples and to detect the mycotoxins present in these samples by using commercially available test kits. The trainees honed their skills working with Innovation Lab staff for six months to develop baseline mycotoxin contamination profiles for wheat to be consumed within the country and for the high value export products. The institutional capacity, in terms of both equipment and trained personnel, offers good chances for increased agricultural exports and improved health for all who live in the country.

Figure 3. MAIL staff preparing a sample of raisins for mycotoxin analysis in the laboratories refurbished and equipped by the Feed the Future Reduction of Post-Harvest Loss Innovation Lab.

Moisture Meters

The Deere Foundation donated $10,000 for the purchase of 40 moisture meters to be used in the four focus countries of this project. These moisture meters are an example of on-the-shelf technology that can be used to reduce post-harvest losses by poor farmers in many rural areas. Investigators with the Feed the Future Reduction of Post-Harvest Innovation Lab working with their in-country collaborators have trained their staff to use these meters to accurately measure grain moisture content on the farms of small farmers, as these crops often are harvested when the moisture content is high. The relatively wet grain stores poorly and is more subject to losses due to microbial colonization, mycotoxin contamination and insect infestation than is drier grain. In Guatemala, promoters are representatives of the in-country partner organization SHARE Guatemala. They live in the Feed the Future areas and are responsible for collecting and submitting grain samples for analysis. Through the training and subsequent sample collection process developed by the project, the promoters and the participant farmers have become more aware of the importance grain moisture in managing grain quantity and grain quality during storage. These promoters and farmers are now active participants in the project's efforts to develop sustainable drying and storage techniques that can be used on their farms.

Figure 4. Staff from SHARE Guatemala and the Feed the Future Reduction of Post-Harvest Loss Innovation Lab prepare to use a John Deere moisture meter to measure moisture content of maize collected in the western Highlands of Guatemala.