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Magazine staff: Joseph C. Walker, Publisher, walker@asabe.org; Sue Mitrovich, Managing Editor, mitro@asabe.org; Glenn Laing, Technical Editor, laing@asabe.org; Melissa Miller, Professional Opportunities and Production Editor, miller@asabe.org; Sandy Rutter, Consultants Listings, rutter@asabe.org; Darrin Drollinger, Executive Director, drollinger@asabe.org.

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ON THE COVER:

***Idaho National Laboratory's Process Demonstration Unit, a full-size, fully integrated feedstock preprocessing system, allows scientists to measure feeding and handling behavior of particulate solids.* Photo courtesy of Idaho National Laboratory.**

American Society of Agricultural and Biological Engineers
2950 Niles Road
St. Joseph, MI
49085-9659, USA
269.429.0300,
fax 269.429.3852
hq@asabe.org, www.asabe.org

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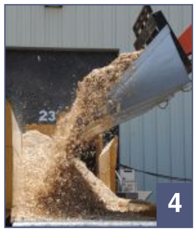
FEATURES



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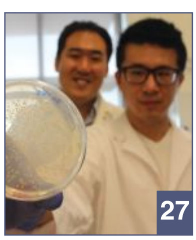


DEPARTMENTS

Reducing Post-Harvest Loss in Developing Countries through the Feed the Future Initiative

Rumela Bhadra

The Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss (PHLIL), housed at Kansas State University (KSU), is a research and education program aimed at improving food security by reducing post-harvest loss of seeds and staple crops, such as grains, oilseeds, and legumes. Feed the Future is the U.S. Government's initiative for food security and ending global hunger in developing countries. PHLIL's efforts are focused in four Feed the Future countries—Bangladesh, Ethiopia, Ghana, and Guatemala—as well as Afghanistan as a short-term engagement. The major goals include:

- Increase the understanding of post-harvest work in rural communities and develop technologies that are usable by all household members.
- Improve drying, handling, and storage technologies to reduce infestation by insects, mold, and fungus.
- Develop technologies with low acquisition costs and limited footprints that are sustainable and accessible to poor farmers.
- Develop creative tools that help non-literate farmers understand and implement the technologies developed as part of the project.
- Develop a standard protocol for conducting baseline surveys of mycotoxin contamination in agricultural products in different countries.
- Increase the quantity and quality of stored food to improve food safety and security for poor farmers.
- Develop strong partnerships with local NGOs to spread information about these technologies to farmers throughout the targeted regions.

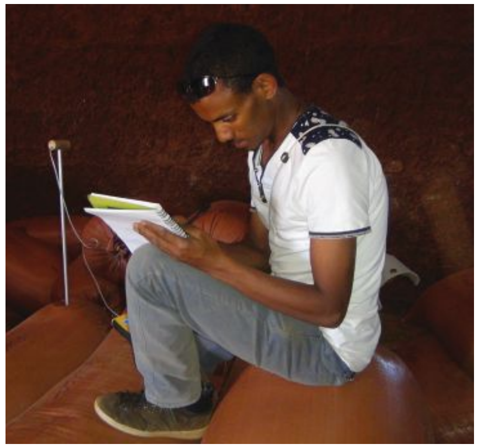
The PHLIL team has a wide variety of partners—universities in the U.S. and other countries, governmental agencies including the USDA-ARS and USAID, private companies like John Deere and GrainPro, and non-profits like the ADM Institute for Prevention of Post-Harvest Loss at the University of Illinois and SHARE in Guatemala. The full list of the partnering institutions can be found on the PHLIL website (www.k-state.edu/phl). KSU houses the management for this international effort.

Sustainable, low-cost grain storage

After a crop is harvested, it must be stored. Pests cause post-harvest losses of 30% to 80% of staple crops and are a major threat to global food security. Some of the grain storage technologies being deployed in by the PHLIL program are ZeroFly® pesticide-impregnated bags, Purdue Improved Cowpea Storage (PICS) bags, and GrainPro® Super Bags. These bags have been proven to protect grain and eradicate common pests. Plans are for mass-scale adoption and sustainable production of these bags in the focus countries. Local grain storage vessels made of terracotta materials and converted plastic water storage tanks are also being tested and evaluated for each country depending on their availability, cost of production, and efficacy in suppressing insect spoilage of stored products for a significant period.

Bhadriraju Subramanyam of KSU *(second from left)* and Rizana Mahroof of South Carolina State University *(far right)* work with students Haile Alebachew *(far left)*, Tesfaye Tadasse *(center)*, and Ethiopian technical agent Dereje Ayalew Zewudie *(second from right)* to sieve insects from white maize at Bahir Dar University.

KSU Distinguished Professor Bhadriraju Subramanyam, whose specialty is stored grain and insect pests, has been heavily involved in Ethiopia, training students at Bahir Dar University and Mekelle University, and establishing curricula for reducing post-harvest losses. As lead scientist for PHLIL's Ethiopia project, Dr. Bhadriraju has helped build the two universities' entomology labs from scratch. After two years of careful training, students are ready to help local farmers with pest control and improved grain storage.



KSU doctoral student Tesfaye Tadasse tests the moisture level for plastic bag storage in a warehouse in Ethiopia.

Efficient crop drying technology

Small-scale farmers who do not have proper crop storage facilities suffer the most losses. Traditional storage methods, such as woven baskets and clay pots, don't prevent fungus and mold. The resulting mycotoxins can cause transitory illnesses, organ failure, immune system suppression, stunting of growth in young children, cancer, and death. Harvested grain is considered wet if the moisture content exceeds 13% by weight, and wet grain is an excellent food source for infestation. Reducing the moisture content reduces these risks and increases the storage life.

A great idea for drying grain in developing countries is the Solar Bubble Dryer, a polyethylene capsule powered by sunshine. Solar drying is economical and sustainable; however, lack of sunshine, high humidity, inconsistent temperatures, and longer drying times are challenges for small-scale farmers. To overcome these challenges, the PHLIL team in Ghana has developed a biomass hybrid solar dryer in which a biomass-fueled heater supplements the solar heat. The biomass fuel can be agricultural residue, wood waste, vegetable waste, or other combustible material. Tests are underway, and the results look promising. Up to five tons of maize can be dried within eight hours, reducing the moisture content from 25% to 12%. Future plans include gas-assisted solar dryers for improved efficiency. The team also built cost-effective plastic crop storage bins that were modified from common water bins. These bulk storage bins are being tested for resistance to mold and insect infestation in maize for up to 12 months.

Solar dryers and hybrid solar dryers are promising for countries like Ethiopia and Ghana, where there is ample sunshine. However, countries that are prone to monsoon rains, like Bangladesh, require non-solar options. To meet this need, team members in Bangladesh have developed a simple, low-cost solution. The STR dryer is composed of bamboo mats, a dryer with generator-compatible electric motors, and a combustible fuel source, such as rice hulls. An STR dryer can be assembled with simple tools and installed indoors, where it occupies very little space. In six hours, an STR dryer can reduce the moisture content in rice enough to allow safe storage for several months in tropical conditions. In the upcoming cropping season, women in four districts in Bangladesh will be given hands-on training with STR dryers.

Low-cost handheld moisture meters

Other PHLIL teams are training local staff in the four focus countries in the use of moisture meters. The Deere Foundation donated funds for the purchase of 40 handheld meters for measuring grain moisture on small farms, where crops often are harvested with high moisture content. These accurate, portable meters are an example of an on-the-shelf technology that can be applied immediately to reduce post-harvest losses for poor farmers in rural areas.

Schematic diagram of a biomass hybrid solar dryer in Ghana.

PHLIL team members install a Solar Bubble Dryer in Ethiopia.

A professor and students at Bangladesh Agricultural University set up an STR dryer for rice.

In Guatemala, the promoters of this program are representatives of our in-country partner organization, SHARE Guatemala. They live in designated Feed the Future areas and are responsible for collecting and submitting grain samples for analysis. Through training and systematic sample collection, the promoters and participant farmers become more aware of moisture management during storage.

Testing a moisture meter with corn samples in Guatemala in collaboration with the SHARE team.

Mycotoxin detection and analysis

PHLIL is actively engaged in detecting and identifying specific mycotoxins in post-harvest crops. Key toxins detected include aflatoxins, fumonisins, deoxynivalenol, ochratoxins, and trichothecenes (including T-2), which are measured with ELISA test kits donated by Romer Labs.

This effort is particularly important in war-torn Afghanistan, which once exported high-quality grapes, raisins, dried fruits, and tree nuts to international markets. Recently, receiving countries have rejected these high-value agricultural products because of fungal toxicities. Not coincidentally, many Afghanis suffer from health problems that are possibly attributable to chronic exposure to mycotoxins.

In Afghanistan, wheat is a suspect food for mycotoxin contamination because it dominates the national diet, with per capita consumption topping 500 g per day. PHLIL has trained staff members of the Afghanistan Ministry of Agriculture, Irrigation, and Livestock in sample collection and detection of mycotoxins using commercially available test kits. The trainees honed their skills for six months and developed baseline profiles for wheat. Outcomes include a strong possibility for improved national health and safer agricultural exports.

Empowering women and improving nutrition

For women in Bangladesh, the real work begins after the rice is harvested. Women preserve, prepare, and serve their family's food. However, unless it is dried and stored properly, freshly harvested rice will quickly become contaminated by fungi, including aflatoxins and fumonisins.

Current drying practices have changed little for thousands of years. The rice is spread on a flat surface and left to dry. The rice is turned once or twice a day with a rake, or sometimes by women simply shuffling their feet through the piles. A big improvement in this age-old process has been to use a tarp or a concrete pad under the crop. Still, drying may require several days, and the rice does not dry uniformly. And while an improved drying space (with a tarp or concrete pad) can help, renting such spaces requires a large share of the family's limited funds. Reducing the time and money that women must spend on drying rice will allow them to use those resources elsewhere. Simple technology, such as low-cost rice dryers and effective storage methods, can greatly improve their quality of life.

Scaling up with international partners

PHLIL is committed to reducing post-harvest loss of staple crops, such as maize, in Ghana. To achieve this goal, PHLIL collaborated with the USDA and private companies, including Vestergaard Frandsen (in Switzerland), John Deere, and GrainPro, for initial lab-scale studies. For expansion and mass-scale adoption of the resulting technologies, Ghana signed Memoranda of Understanding with national and international agricultural organizations, including the Ghana Agriculture Technology Transfer project (ATT), Africa RISING, and SPRING. ATT has expressed interest in constructing three solar dryers for use with warehouse trials in Ghana and will purchase USDA moisture meters.

ASABE member Sam McNeill ***(left)*****, University of Kentucky extension agricultural engineer, explains the low-cost grain moisture meter developed by the USDA-ARS.**

Staff members at the Afghanistan Ministry of Agriculture, Irrigation, and Livestock prepare a sample of raisins for mycotoxin analysis in the lab refurbished and equipped by PHLIL.

Africa RISING and SPRING will help the Ghana team collect mycotoxin baseline data. Additional pest infestation data from the warehouses and on-farm storages will be collected by ATT and SPRING. Large-scale adoption of ZeroFly storage bags (made by Vestergaard Frandsen) will be a collaborative process between the PHLIL team in Ghana and ATT, Africa RISING, and SPRING. The Ghana team has also received a $40,000 grant from the USDA Scientific Cooperation Research Program to build a biomass hybrid solar dryer. The Adventist Development and Relief Agency (ADRA) in Ghana is scaling up as well.

These kinds of collaborations are hugely beneficial for mitigating post-harvest loss. The ongoing work builds on the expertise of international agricultural programs as well as local stakeholders, local farmers, and local private industries. A surprising outcome from these collaborations was discovering how important the new technologies were to the Ghana Poultry Project (GPP), which needs grain dryers and moisture meters for quality control of its maize-based chicken feed. The new technologies allow GPP to meet the demands of important clients, such as Kentucky Fried Chicken, which now purchases about $2 million of poultry per year from GPP. Similar happy surprises are occurring across the focus countries.

ASABE member Rumela Bhadra, Research Associate, Department of Biological and Agricultural Engineering, Kansas State University, Manhattan, USA, rumelabhadra31@gmail.com.

Dr. Bhadra works under a joint collaboration of KSU's Department of Biological and Agricultural Engineering and the USDA-ARS Center for Grain and Animal Health Research in Manhattan, Kansas. Dr. Bhadra served as the program coordinator for KSU's Feed the Future Innovation Lab for the Reduction of Post-Harvest Loss from October 2015 to October 2016. For current updates and information about the Innovation Lab, visit www.k-state.edu/phl. For more information on the Feed the Future Initiative, visit www.feedthefuture.gov.

ASABE member Paul Armstrong gives hands-on training in mycotoxin detection for students in Ghana ***(left)*****, Armstrong and PHLIL team members use a moisture meter to test corn at a local market** ***(center)*****, Armstrong presents moisture meter and storage bag results to a group of farmers and stakeholders** ***(right). Editor's note: See page 24 for further news on Armstrong and the USDA-ARS moisture meter.***