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Feed the Future Innovation Lab for Collaborative Research on Peanut Productivity and Mycotoxin Control

Annual Report – Fiscal Year 2014

FEED THE FUTURE
PEANUT & MYCOTOXIN INNOVATION LAB

Feed the Future Innovation Lab for Collaborative Research on Peanut Productivity and Mycotoxin Control

(Peanut & Mycotoxin Innovation Lab)

Annual Report – Fiscal Year 2014

(1 October 2013 – 30 September 2014)

PMIL Management Entity
The University of Georgia, Athens, Georgia
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Note from the Director

Dave Hoisington investigating peanuts in a farmer's field in Haiti.
Photo courtesy of Christy Fricks.

On behalf of the entire research and management team, it is my pleasure to present the Feed the Future Innovation Lab for Collaborative Research on Peanut Productivity and Mycotoxin Control Annual Report for Fiscal Year 2014 (FY2014). The Feed the Future Innovation Lab for Collaborative Research on Peanut Productivity and Mycotoxin Control, otherwise known as the Peanut & Mycotoxin Innovation Lab or PMIL, is in its second year of operation since being restructured at the end of the previous phase in 2012. During the first year (FY2013), efforts were focused on establishing a new project portfolio based on an open competitive bid for proposals and appointing a new Management Team to be based at the Athens Campus of the University of Georgia. As such, only a few research projects were approved by the end of the FY2013, and even these were only beginning operations. Thus, FY2014 is the first reporting year in which most of the projects have been in operation for a significant portion of the year, although as noted in the report, the projects focused on value chain interventions in Africa were only approved and initiated towards the end of the fiscal year.

I believe you will find that PMIL is already making excellent progress in addressing some of the key constraints facing smallholder peanut farmers in developing countries. Our efforts building on the successes in genomics, genetic engineering and breeding are providing better varieties to be tested in farmers' fields and ultimately disseminated in the country and region. Mycotoxin contamination remains a challenging issue and PMIL is researching new detection and sampling methods that hold promise as prototypes in the coming year. Peanuts are well known for their nutritional value in addressing severe malnutrition. A new study underway with PMIL support is looking at cases of mild malnutrition in pregnant women to determine the role that peanut-based products could have in addressing low-weight births. Finally, our projects addressing interventions along the peanut value chain are well underway and in some cases, e.g. Haiti, are having impacts through improved access to inputs and markets by peanut farmers.

We welcome feedback from all stakeholders and please make sure you register to receive our eNewsletter and follow us on social media.

Dave Hoisington, Director, PMIL

Acronyms

AFB	Aflatoxin B
AOR	Agreement Officer's Representative
APHIS	Animal and Plant Health Inspection Service, USA
ASU	Albany State University, Albany, GA
CAES	College of Agricultural and Environmental Sciences
CERAAS	Centre d'Etude Régional pour l'Amélioration de l'Adaptation á la Sécheresse, Senegal
CNRA	Centre National de Recherches Agronomiques, Senegal
Co-PI	co-Principal Investigator
COMESA	Common Market for Eastern and Southern Africa
CRI	Crops Research Institute, Ghana
CRP	CGIAR Research Program
CRSP	Cooperative Research Support Program
CSB+	Corn Soy Blend
CSB-P	CSB plus multiple micronutrient tablet
CSIR	Counsel for Scientific and Industrial Research, Ghana
DBS	Dried Blood Sample
EAP	External Advisory Panel
FY2013	Fiscal Year 2013
FY2014	Fiscal Year 2014
FY2015	Fiscal Year 2015
GWAS	Genome-Wide Association Study
HACCP	Hazard and Critical Control Points
HIV	Human Immunodeficiency Virus
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
IIAM	Instituto de Investigação Agrária de Moçambique, Mozambique
IITA	International Institute for Tropical Agriculture, Nigeria
ISRA	Institut Sénégalais de Researches Agricoles, Senegal
KNUST	Kwame Nkrumah University of Science and Technology, Ghana
LUANAR	Lilongwe University of Agriculture and Natural Resources, Malawi
ME	Management Entity
MoFA	Ministry of Food and Agriculture, Ghana
MSc	Master of Science Degree
MSU	Mississippi State University, MS
MUAC	Mid-Upper Arm Circumference
NaCRRI	National Crops Resources Research Institute, Uganda
NARO	National Agricultural Research Organization, Uganda
NaSARRI	National Semi-Arid Resources Research Institute, Uganda
NASFAM	National Smallholder Farmers Association of Malawi, Malawi
NBCRI	Norman Borlaug Commemorative Research Initiative
NCSU	North Carolina State University, NC
NGO	Non-Governmental Organization
NPRL	National Peanut Research Lab, Dawson, GA
PCR	Polymerase Chain Reaction
PhD	Doctor of Philosophy Degree
PI	Principal Investigator
PIIM	Peanut Industry Incubator Model
PMIL	Peanut & Mycotoxin Innovation Lab
RDA	Recommended Daily Allowance
RNAi	RNA interference
RSS	Rich Site Summary
RUSF	Ready-to-Use Supplemental Food
RUSF-P	Ready-to-Use Supplemental Food plus 200% micronutrients in pregnancy
RUTF	Ready-to-Use Therapeutic Food
SARI	Savannah Agricultural Research Institute, Ghana
SNP	Single Nucleotide Polymorphism
SPAD	Soil Plant Analysis Development
SSR	Simple Sequence Repeat
STN-PCR	Single Tube Nested Polymerase Chain Reaction
TNAU	Tamil Nadu Agricultural University, India
UDS	University for Development Studies, Ghana
UFL	University of Florida, FL
UGA	University of Georgia, GA
UHPLC	Ultra-High Performance Liquid Chromatography
UNZA	University of Zambia, Zambia
USAID	United States Agency for International Development, USA
USDA	United States Department of Agriculture
USDA-ARS	United States Department of Agriculture – Agricultural Research Service
WU	Washington University, St Louis, MO
ZARI	Zambian Agricultural Research Institute, Zambia

Executive Summary

During the past year, a full Management Team has been put in place, all initial projects approved and sub-awards issued. In addition, two research meetings were conducted involving PMIL researchers, PMIL and USAID management, PMIL External Advisory Panel members and country partners. Both of these meetings helped the PMIL research community come together as a single program team and better define each proposed research project.

On the research front, excellent progress has been made in many of the projects. The sequencing of the two progenitor genomes of cultivated peanut has opened new opportunities to map traits such as drought tolerance, insect and disease resistance, and quality aspects like high oil content, oleic to linoleic acid ratio, and iron and zinc content. Even modern genomic selection approaches such as Genome-Wide Association Studies (GWAS) are now feasible and being investigated for improving the efficiency of peanut variety development. The use of genetic engineering to inhibit the contamination of peanuts by mycotoxins may be the only possibility to fully control mycotoxins in peanut. Initial results look promising for such an approach. The use of these and other modern approaches are being incorporated into the peanut breeding programs in the USA and partner countries. New varieties are in the pipeline and are being evaluated on-station and in farmers' fields. Some are now being released for wide-scale production as outlined in one of the Success Stories (see Appendix C1).

The detection and monitoring of mycotoxin contamination remains a major challenge and new options are beginning to take shape thanks to PMIL research. AflaGoggles are in the early prototype stage and could provide a relatively simple visual method to detect the presence of mycotoxins in corn, peanuts and other commodities. Results have demonstrated that the new digital imaging technology greatly enhances the detection of mycotoxins, well beyond that of the human eye. Techniques to better take blood samples in the field and transport these safely to analysis laboratories are proving feasible.

While peanuts are well known for their nutritional value as a natural food and in Ready-To-Use Therapeutic Foods (RUTF), less is known about their value in treating mild malnutrition, especially in pregnant women. A PMIL project has initiated such a study in Malawi and has 170 women enrolled to test the effects of peanut-based food to reduce occurrences of low-weight and stunted births.

Putting all of the advanced research together are the three value chain projects in Haiti, Ghana and across the three countries in Southern Africa (Malawi, Mozambique and Zambia). Each is evaluating the effect of several interventions in the pre- and post-harvest value chains to determine not only the effect on improving peanut production, but also the reduction in mycotoxin contamination. In addition, the economics and acceptance of each intervention is being studied to best determine those interventions ready for scaling-up and out in each country. Results from work in the previous phases of PMIL (previously known as the Peanut CRSP) have shown significant outcomes in Haiti where the recent launch of the Acceso Peanut Enterprise Corporation by former President Bill Clinton and Frank Guistra demonstrated the impact that research and backstopping by PMIL scientists in the country can have to spur investment. The company's network of depots is becoming a major source of inputs (seeds, fertilizer and knowledge) for smallholder farmers, and buying/selling points for the farmer's production (see PMIL Success Story in Appendix C2).

In closing, PMIL is now in full operation and focused on making an impact in each of the countries where it is working. Achieving success will not be easy, nor often quick, but through team work involving all PMIL scientists and partners, we are certain that smallholder farmers and their families will be producing more and better peanuts, and reaching local, regional and global markets in the future.

Program Countries

PMIL primary target countries include: Ghana, Haiti, Malawi, Mozambique and Zambia. In addition to the primary countries and the USA, PMIL has research activities in Burkina Faso, India, Kenya, Mali, Nigeria, Senegal and Uganda.

Program Partners

PMIL works with universities and other institutions located in 15 US States (Alabama, California, Connecticut, District of Columbia, Florida, Georgia, Louisiana, Maine, Missouri, Mississippi, North Carolina, New Mexico, New York, Texas and Virginia) and 12 foreign countries (see above list). Details on the specific institutions in each US State and foreign country are provided in Appendix A.

Program Highlights

- Participated in the launch of the Acceso Peanut Enterprise Corp with President Bill Clinton and philanthropist Frank Guistra. This Haitian for-profit venture, funded by the Clinton Guistra Enterprise Partnership, is a commercialization and expansion of much of the research under PMIL to train farmers and supply appropriate inputs to meet the growing demand for high quality peanuts in Haiti. PMIL continues to provide evidence-based advice and evaluate new technologies to improve this venture. (See Appendix C2)
- A production guide entitled *Integrated Practices to Manage Diseases, Nematodes, Weeds and Arthropod Pests in Ghana* (Owusu-Akyaw, Mochiah, Gyasi-Boakye, and Asafu-Agyei, editors) representing many years of previous collaborative research was completed and printed in Ghana and distributed to university, national program, NGO and contributing scientists.
- Provided for more efficient and effective methods to screen for mycotoxin contamination in human subjects by evaluating several commercially available Dried Blood Sample (DBS) cards for their accuracy to hold different quantities of whole blood, developing different washing strategies for efficiency to elute bound blood components, and optimizing conditions to detect aflatoxin in the eluted samples.
- Disseminated the importance and availability of improved peanut varieties in Uganda, via major regional media outlet. (http://paulndiho.com/2014/02/20/ugandan-groundnut-farmers-cashing-in-on-improved-new-varieties/). (See Appendix C1)
- All remaining staff for the Peanut & Mycotoxin Innovation Lab (PMIL) Management Entity (Assistant Director, Web Developer and Communications Specialist) were hired and actively involved in PMIL management, including the deployment of a new website (pmil.caes.uga.edu) and active communications via numerous social media venues.
- Transformed feedback from PIs at the July annual meeting concerning the limited understanding of mycotoxin variability and sampling protocols into a new research relationship with the USDA-ARS for Peanut Quality. Initial work on these issues has yielded tremendous response from other researchers in the field and developed new research questions critical to scaled testing in Africa.

Key Accomplishments

- **New genomic technology** – a SNP (single nucleotide polymorphism) discovery pipeline developed that allows true SNPs to be called with high confidence, and sequencing of additional genotypes underway to expand the pool of SNPs that can be used for genotyping.
- **New germplasm evaluated** – over thirty entries originating from the "aflatoxin groundnut core" evaluated in both US and Niger locations; trials at CRI and SARI, Ghana established that include sixteen ICRISAT lines and six promising lines from Ghana.
- **New varieties being readied for release** – Valencia varieties from the USA are undergoing yield trials in Mozambique; fourteen groundnut lines with resistance to groundnut rosette disease and early leaf spot disease in National Performance Trials in Uganda. Seed increase of promising groundnut variety with Kreyol, Inc. and iF Foundation in Haiti.
- **New mycotoxin sampling technology** – several commercially available dried blood sample cards were evaluated for their accuracy to hold different quantities of whole blood, developed different washing strategies for efficiency to elute bound blood components, and established methods to measure concentrations of total proteins and albumin in diluted micro-volume washing solutions.
- **New mycotoxin detection technology** – optimized conditions of enzyme digestion to release aflatoxin B-bound lysine adduct from the protein, develop method for concentration and purification of the adduct in digests, determine analytical parameters, such as accuracy, precision, sensitivity (limit of detection), reproducibility, and recovery for the method, and validated the method using whole blood of rats.
- **Additional mycotoxin level data produced** – analyzed aflatoxin B-lysine adduct for serum samples collected from East Timor and Kenya human population studies conducted by collaborators in the Nutrition Innovation Lab.
- **Nutritional study initiated** – a total of 170 nutrition study participants have been enrolled across the six study sites in Malawi and are reporting bi-weekly for follow-up. Began conducting home visits in Malawi to collect adherence information, household food inventory and to obtain a 24-hour dietary recall.
- **Improved capacity of local partners** – established an aflatoxin detection facility at iF Foundation in Haiti, and provided training to staff to operate and maintain the facility. Trained 40 pilot farmers, two University of Development Studies graduate students and one Ministry of Agriculture extension agent in Ghana on post-harvest aflatoxin prevention.
- **Disseminated latest information to partners** – reprinted peanut production guide '*Gid pou Pwodiksyon Pistach nan Savann Rupununi*' (R.C. Kemerait and Jerry LaGra, editors) and distributed copies to partners in Haiti.
- **Building human capacity** – Ghanaian PhD student graduated from UGA Food Science and returned to Ghana to establish a research program on peanut food science. Three Ghana nationals enrolled at KNUST, Ghana in agronomy and pest management, agricultural engineering (postharvest handling and storage), and food science (processing); one female PhD student from Ghana enrolled at the University of Georgia; one senior student (female) and two graduate students (one female, one male) undergoing training in *Aspergillus* diversity assessment at National Peanut Research Laboratory, Georgia.

Research Program Overview and Structure

The PMIL aims to increase the productivity and profitability of peanut production for smallholder farmers and to reduce the negative impacts of mycotoxin contamination along the value chain of peanut and other crops in five Feed the Future countries – Haiti, Ghana, Malawi, Mozambique and Zambia. The research program is broadly organized into three main areas: (a) peanut germplasm development, (b) mycotoxin detection and peanut nutritional studies, and (c) peanut value chain interventions to increase quantity, decrease mycotoxin contamination and enhance economic returns to smallholder farmers. The FY2014 program involved the following ten research projects coordinated by a Project Investigator located at five US universities and one USDA-ARS location.

Research Project Title	Project Investigator	Lead Institution
A. Peanut Germplasm Development		
A1. Translational Genomics to Reduce Pre-harvest Aflatoxin Contamination of Peanut	Peggy Ozias-Akins	University of Georgia
A2. Silencing of Aflatoxin Synthesis through RNA Interference (RNAi) in Peanut Plants	Renee Arias	USDA-ARS National Peanut Research Laboratory
A3. An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality	C. Michael Deom	University of Georgia
B. Mycotoxin Detection and Peanut Nutritional Studies		
B1. AflaGoggles for Screening Aflatoxin Contamination in Maize	Haibo Yao	Mississippi State University
B2. Development and Validation of Methods for Detection of Mycotoxins Exposure in Dried Spotted Blood Samples	Jia-Sheng Wang	University of Georgia
B3. Randomized Controlled Trial of the Impact of Treating Moderately Malnourished Women in Pregnancy	Mark Manary	Washington University - St. Louis
C. Peanut Value Chain Interventions		
C1. Production to Consumption – Technologies to Improve Peanut Production, Processing and Utilization in Haiti	Greg MacDonald	University of Florida
C2. Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana	David Jordan	North Carolina State University
C3. Producer and Consumer Interventions to Decrease Peanut Mycotoxin Risk in Ghana	Nicholas Magnan	University of Georgia
C4. Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia	Rick Brandenburg	North Carolina State University

Research Project Reports

A. Peanut Germplasm Development

Project A1. Translational Genomics to Reduce Pre-harvest Aflatoxin Contamination of Peanut

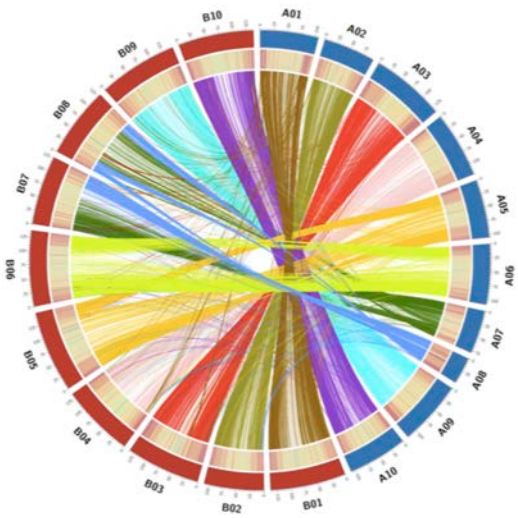


Diagram of the chromosomal relationships of peanut based on its genome sequence. Photo courtesy of Peggy Ozias-Akins.

The goal of the project is to associate molecular variation with resistance to pre-harvest aflatoxin contamination on a genome-wide scale and to utilize this information in breeding programs. To achieve the goal, both genotyping and highly replicated phenotyping for aflatoxin contamination are required. Genotyping with genome-wide SNP markers is being enabled by peanut genome sequence information, both from cultivated tetraploid genotypes as well as diploid progenitors of the tetraploid. A SNP discovery pipeline has been developed that allows true SNPs to be called with high confidence. Sequencing of additional genotypes relevant to the project is underway to expand the pool of SNPs that can be used for genotyping. Both transcriptome and genome sequences are being used for SNP discovery. A pilot sequence-based-genotyping study showed that SNPs called were distributed randomly across the A and B genomes of peanut based on alignment with the diploid genome pseudo-molecules. Similarly, transcripts representing A and B homeologs in tetraploid peanut also mapped across the genome in an expected pattern of increased density towards the ends of chromosomes. Whether to use sequence-based genotyping or a SNP chip for genotyping is still undetermined, but the choice will be based on economy and required depth of information.

Collaborators

Name	Institution	Country	Role
Peggy Ozias-Akins	University of Georgia	USA	PI
David Bertioli	University of Brasilia/University of Georgia	Brazil/USA	Co-PI
Rajeev Varshney	ICRISAT	India	Co-PI
Haile Desmae	ICRISAT	Mali	Co-PI
Issa Faye	ISRA	Senegal	Co-PI
Daniel Fonceka	ISRA	Senegal	Co-PI
Corley Holbrook	USDA-ARS	USA	Co-PI
Scott Jackson	University of Georgia	USA	Co-PI
Hari Upadhyaya	ICRISAT	India	Partner
Pasupuleti Janila	ICRISAT	India	Partner
Pawan Khera	ICRISAT	India	Partner

Achievements

Phenotyping is underway in the USA, Senegal and Niger. All entries have a minimum of three and a maximum of ten replications for each, grown under late-season drought stress that is either naturally occurring or imposed. Plots of the chromosome segment substitution lines in Senegal already have been harvested, while planting in the USA and Niger occurred in June and July 2014, respectively. Over thirty of the entries originating from the "aflatoxin core" are being tested in both US and Niger environments.

Capacity Building

None during this year, although progress has been made to identify PhD students to participate in the research program. The selected students will start by Fall 2015.

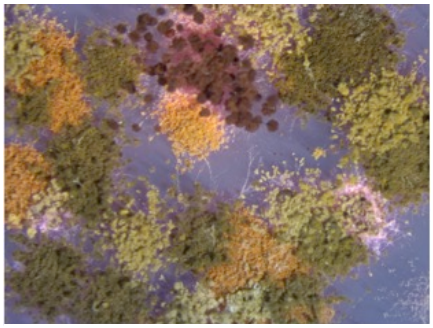
Lessons Learned

From the first year, we have learned that while international collaborations are logistically challenging, they can be very productive, especially in areas like genomics that require multiple inputs to achieve the goals. We have also realized that identifying true single-nucleotide polymorphisms (SNPs) in cultivated peanut requires special bioinformatics approaches compared to most other polyploidy crops. Another reason for establishing international partnerships.

Presentations and Publications

Presentations on the project have only been internal to the program at this point except that the SNP discovery pipeline was presented at the American Peanut Research and Education Society meetings in July 2014 by graduate student Josh Clevenger, who is not on PMIL funding, but nonetheless is contributing to the project. The title was 'Single Nucleotide Polymorphism (SNP) detection in cultivated peanut using the diploid wild progenitor reference genomes.' No publications yet to report.

Project A2. Silencing of Aflatoxin Synthesis through RNA Interference (RNAi) in Peanut Plants



Diversity of Aspergillus species in a peanut sample from Ethiopia. Photo courtesy of Renee Arias.

The overall goal of this project is to use RNA interference (RNAi) to reduce aflatoxin in peanut seeds. The research is divided in two parts, one is the study of genetic diversity of aflatoxigenic *Aspergillus* species funded by PMIL, and the other is the genetic transformation of peanut plants using RNA interference that is funded by NBCRI. For the genetic diversity studies, an agreement has been executed with NARO in Uganda, and an agreement with ICRISAT in Malawi is at the collaborator for signature. At the National Peanut Research Laboratory (NPRL), a student from Albany State University (ASU) was trained on DNA extractions from *Aspergillus*, a graduate from Emory University is being trained on bioinformatics, and a student from Haramaya University in Ethiopia is working on isolating and identifying *Aspergillus* strains from 80 samples collected from that country. For peanut transformation, a method developed at the NPRL for runner peanut is being tested on African cultivars; an agreement with Kenyatta University (Kenya) that will include the training at the NPRL of students and scientists from Kenya has been executed. Genetic transformation of peanut plants with RNAi has been started at the NPRL, a student from ASU was trained on molecular techniques for screening transgenic plants, and approximately 47% of the plants tested were confirmed as transgenic. In addition, an accurate method

of quantification of aflatoxins in single peanut seeds or fractions of a seed using Ultra-High Performance Liquid Chromatography has been developed at the NPRL.

Collaborators

Name	Institution	Country	Role
Renée Arias	USDA-ARS National Peanut Research Lab	USA	PI
Steven Runo	Kenyatta University	Kenya	Co-PI
Samuel Njoroge	ICRISAT	Malawi	Co-PI
Phat Dang	USDA-ARS National Peanut Research Lab	USA	Co-PI
Victor Sobolev	USDA-ARS National Peanut Research Lab	USA	Co-PI
Julius Sserumaga	National Crops Resources Research Institute	Uganda	Partner
Charles Chen	Auburn University	USA	Partner

Achievements

With PMIL funding:

- APHIS permits that allowed NPRL to import pure cultures of *Aspergillus* species and *Aspergillus* DNA were expanded to include the import of contaminated seeds/soil samples for laboratory analysis.
- An agreement has been executed with NARO, Uganda, to bring samples from Uganda and Kenya to ICRISAT in Malawi for processing for the genetic diversity studies of *Aspergillus* species.
- A senior student (female), LaTanya Johnson, from ASU was hired at the NPRL and trained in large scale DNA extraction from *Aspergillus*, she completed extractions for selected type strains to test our work-flow from high-throughput sequencing to bioinformatics, which will be used with samples from Sub-Sahara African countries.
- A graduate (female), Monica Wang, from Emory University was hired and is being trained at the NPRL on bioinformatics to assist in the genetic diversity analyses.
- A PhD student from Haramaya University, Ethiopia, is currently receiving training at the NPRL, while processing 80 samples of peanut from his experiments in that country. The processing includes, isolation and characterization of aflatoxigenic strains of *Aspergillus*, DNA isolation, use of molecular markers to compare strains, perform aflatoxin analysis of the peanut samples, learn various pieces of software to work with the data generated.

With NBCRI funding:

- A senior student (female), LaTanya Johnson, from ASU was hired at the NPRL and trained in DNA extractions from peanut plants and on PCR to screen transgenic plants, and she put in place a STN-PCR technique to increase sensitivity of transgene detection. She screened 108 putative transgenic plants and confirmed 47% as transgenic for one RNAi construct.
- A senior student (female), Sharee Bursch, from ASU was hired to help on tissue culture and RNA extractions to assist in genetic transformation of peanut plants.
- One more growth chamber was purchased with NBCRI funding to scale up transformation activity at the NPRL.
- An agreement has been executed with Kenyatta University, Kenya to start a peanut biotechnology program at that location by first training their personnel at the NPRL, students and scientists will learn genetic transformation of peanut at the NPRL. We have started the paperwork to bring Mr. Paul Macharia Karanja, MSc student of biotechnology at Kenyatta University, to receive training on peanut-genetic transformation and molecular tools.

Capacity Building

A postdoc has been selected, Dr. Imana Power (female) from Suriname, to work on both projects, genetic diversity of *Aspergillus* and use of RNAi for genetic transformation of peanut. All the documentation has been submitted for her hiring, we are waiting for approval from the administration.

A MS student from Kenya has been selected to come to the NPRL from training; his paperwork is being processed at USDA-ARS. Funding for a postdoc was 50% covered by PMIL and 50% by NBCRI, thus, the recruiting of a candidate started after both sources of funding were in place.

Lessons Learned

There is a tremendous potential in hosting visiting students, both in moving forward the research project, but also in building capacity in the partner institutes, that gives us high expectations that the investments we are doing in training will be worthwhile.

Presentations and Publications

None during FY2014.

Project A3. An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality

Peanut varieties being tested for diseases in a field site in Ghana. Photo courtesy of Mike Deom.

The overall goal of this project is to use breeding and outreach to enhance the production, quality and marketability of peanut in PMIL target countries. The proposed research focuses on intensifying peanut production and enhancing quality by developing and improving high yielding varieties, including the release of new cultivars and the development of culturally preferred cultivars, through existing and established breeding programs. Biotic stresses are addressed by focusing on developing new and improving existing varieties with resistance to economically important pathogens and pests, while the primary abiotic stress addressed will be drought tolerance and avoidance, a trait that factors into mitigating aflatoxin contamination. The breeding program will also focus on value added traits, including high oleic content (nutrition and shelf-life), increased micronutrient density (iron and zinc), high oil content (cooking oil and butter) and large seeds (edible market). Outreach programs will be used to stress technology transfer and the value of new cultivars and system considerations for utilizing management strategies. Considerable resources will be directed to host countries for capacity building, including student training, scientist training and infrastructure improvements. As advanced varieties become available, they will be distributed to PMIL target country collaborators and PMIL value chain projects for evaluation as well as other developing countries that request the material.

The outcome of the research will result in the development and adoption of improved cultivars that will result in increased yields and increased quality. Subsequent benefits will result in improved peanut value chains, increased food security, better nutritional and dietary traits and increased income throughout PMIL target countries as well as other developing countries. Capacity building will result in in-country

knowledge, expertise and improved infrastructure, which will build a foundation to continue improving peanut yields and quality.

Collaborators

Name	Institution	Country	Role
Carl Mike Deom	University of Georgia	USA	PI
Phillippe Sankara	University of Ouagadougou	Burkina Faso	Co-PI
Nicholas Denwar	SARI	Ghana	Co-PI
Subbarayalu Mohankumar	TNAU	India	Co-PI
Patrick Okori	ICRISAT	Malawi	Co-PI
Amade Muitia	IIAM	Mozambique	Co-PI
Gayi Dennis	NaSARRI	Uganda	Co-PI
David Okello	NaSARRI	Uganda	Co-PI
Noelle Barkley	USDA-ARS	USA	Co-PI
Boris Bravo-Ureta	University of Connecticut	USA	Co-PI
Mark Burow	Texas A&M University	USA	Co-PI
Rangaswamy Muniappan	Virginia Tech	USA	Co-PI
Greg MacDonald	University of Florida	USA	Co-PI
Naveen Puppala	New Mexico State University	USA	Co-PI
Charles Simpson	Texas A&M University	USA	Co-PI
Barry Tillman	University of Florida	USA	Co-PI

Achievements

- High oleic Valencia peanut variety released in USA.
- High iron and zinc traits crossed with high oleic Valencia.
- Commercial US Valencia varieties undergoing yield trials in Mozambique.
- Valencia populations developed at ICRISAT for high SPAD (leaf chlorophyll content as a possible inexpensive selection tool for water-use efficiency), cold tolerance and early maturity, and drought tolerance.
- Populations being screened for rust and late leaf spot resistance in Africa and late leaf spot and white mold resistant in Haiti.
- Evaluation of cultivars for primed acclimation.
- Screening for early and late leaf spot resistance and yield in Ghana and Burkina Faso.
- Develop populations with enhanced potential for drought tolerance.
- Crosses made for high oleic and large seeds.
- Seed increases in Ghana for early and late leaf spot resistant lines.
- SSR markers developed for yield under drought stress.
- Initiated SNP-based mapping of peanut genome.
- India leaf miner population genotyped.
- Leaf miner larvae in Uganda collected for genotyping.
- Fourteen lines, most with resistance to groundnut rosette disease and early leaf spot disease, being evaluated in National Performance Trials in Uganda.
- Documentation of variety development in Uganda (http://paulndiho.com/2014/02/20/ugandan-groundnut-farmers-cashing-in-on-improved-new-varieties/).

- Screening for new sources of resistance and advancing identified sources of resistance to drought, early leaf spot and groundnut rosette disease in Zambia.

Capacity Building

Greenhouse under construction at NaSARRI, Uganda. Weather station for Burkina Faso. Aphid rearing facility under construction in Zambia.

Lessons Learned

Valencia trials in Mozambique are showing some promising yields. Cold storage facilities are needed in many countries to provide quality seed from season to season, and to enhance germplasm conservation. Irrigation is needed for sustainable drought screening. Procurement processes often delay purchases that are required promptly in many countries. Early bulking of seed of pre-releases is a good practice to avert seed crisis post-release.

Project Presentations and Publications

Presentations

Opportunities and challenges in the oilseeds value chain: researcher's perspective; 24th and 25th June, 2014 in Kitgum and Lamwo Districts, Uganda

Groundnuts for improved income and livelihoods 18th July, 2014 in Gulu, Oil Seed Subsector Platform (OSSUP) Multi-Stakeholders Workshop

DK Okello, M Biruma, P Okori and CM Deom. (2013) Groundnut improvement in Uganda. CGIAR Generation Challenge Programme, (2013) September 27−30 2013 Lisbon, Portugal General Research Meeting Poster Abstracts. Hosted by the International Maize and Wheat Improvement Center Texcoco, Mexico: Generation Challenge Programme. www.generationcp.org

Publications

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Okello, D. K., Monyo, E., Deom C.M., Ininda, J., & Oloka, H. K. 2013. Groundnuts production guide for Uganda: Recommended practices for farmers. National Agricultural Research Organisation, Entebbe. ISBN: 978-9970-401-06-2. http://www.naro.go.ug/Information/narodocuments/Groundnut%20production%20guide%20-%20Recommended%20practices%20for%20farmers.pdf

Olwari F, Bisikwa J, Kaaya AN, Okello DK. (2013) Tolerance Levels of Peanut Varieties against *Aspergillus flavus* Infection. *J Plant Pathol Microb* 4: 195. doi:10.4172/2157-7471.1000195

Ozimati A.A., Rubaihayo P.R., Gibson P., Edema R., Kayondo I.S., Ntare B.R., Okello D.K. (2014). Inheritance of resistance to kernel infection by *Aspergillus flavus* and aflatoxin accumulation in groundnut. *African J Crop Sci* 2 (1): 51-59.

B. Mycotoxin Detection and Peanut Nutritional Studies

Project B1. AflaGoggles for Screening Aflatoxin Contamination in Maize

Examples of possible Aflagoggle prototypes. Photos courtesy of Haibo Yao.

Aflatoxin contamination in maize is a major food safety issue worldwide. The problem is of special importance in African countries because maize is used as a staple food. A primary limitation to controlling ingestion of contaminated food in these countries is the lack of affordable and feasible methods for farmers on small village farms to screen for aflatoxin contamination. Due to the high cost associated with any existing aflatoxin detection methods, it is of urgent need to develop portable, rapid, and non-invasive technology for aflatoxin detection in maize for these farmers. The goal of the project is to develop portable, fluorescence spectral-based technology for rapid and non-invasive aflatoxin detection in maize. A detection device, AflaGoggle, will be developed in the project.

Collaborators

Name	Institution	Country	Role
Haibo Yao	Mississippi State University	USA	PI
Alpha Kamara	International Institute for Tropical Agriculture	Nigeria	Co-PI
Robert Brown	USDA-ARS	USA	Co-PI

Achievements

The project team has finished Objective 1: survey existing methods for low-cost, rapid, and non-invasive screening of aflatoxin contamination in maize, and Objective 2: survey current applications using narrow bandwidth filtering. Two summary reviews have been generated to guide the on-going research. Maize samples have been collected from a 2014 experiment field.

Capacity Building

One postdoc was employed to work on the project (50% effort) and began duties on September 2, 2014.

Lessons Learned

We have learned that human eyes have very low sensitivity in the desired spectral range for aflatoxin contamination detection. The focus of research will be more on electronic filtering.

Presentations and Publications

Yao, H. and W. Burger, AflaGoggles for Screening Aflatoxin Contamination in Maize. Presented to Dr. Robert Bertram, Director, Office of Agricultural Research and Policy, Bureau for Food and Security, USAID, 01/28/2014, Starkville, MS.

Yao, H., Hruska, Z., Kincaid, R., Brown, R., Clevelend, T., & Bhatnagar, D. Fluorescence emission spectra of internal cross-section of maize kernels infected with *Aspergillus flavus*. Book of Abstracts of the International Mycotoxin Conference 05/19-23, 2014. Beijing, China: ISM.

Project B2. Development and Validation of Methods for Detection of Mycotoxins Exposure in Dried Spotted Blood Samples

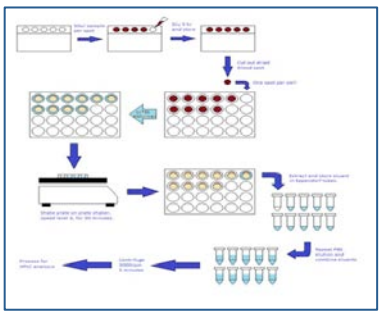

Diagram of procedure for analyzing dried blood samples. Diagram courtesy of JS Wang.

The goal of this project is to establish and validate methods for measuring major mycotoxin biomarkers, especially for aflatoxin-lysine adduct, in human dried blood spot samples for supporting urgent needs of nutritional and intervention studies conducted in Asia and Africa countries by the Peanut & Mycotoxin Innovation Laboratory as well as the Nutrition Innovation Lab. The methods will be validated and applied to assess susceptibility factors in determination of human aflatoxicosis, to evaluate the linkage between AF exposure and human nutrition deficiency and growth retardation and developmental inhibition in children.

Collaborators

Name	Institution	Country	Role
JS Wang	University of Georgia	USA	PI
Nii-Ayi ANkrah	University of Ghana	Ghana	Co-PI
Justice Kumi	University of Ghana	Ghana	Co-PI
Jeffrey Griffiths	Tufts University	USA	Co-PI
Patrick Webb	Tufts University	USA	Co-PI

Achievements

In this funding year we focused on Phase 1 objectives, i.e. development of a method for measurement of aflatoxin B_1 (AFB)-Lysine adduct in dried blood samples (DBS). We evaluated various commercially available DBS cards for their accuracy to hold different quantity of whole blood, developed different washing strategies for efficiency to elute bound blood components, especially for elution of total protein and albumin spotted on DBS card, and established methods to measure concentrations of total proteins and albumin in diluted micro-volume washing solutions. We further optimized conditions of enzyme digestion to release AFB-bound lysine adduct from the protein, develop method for concentration and purification of AFB-lysine adduct in digests, and determine analytical chemistry parameters, such as accuracy, precision, sensitivity (limit of detection), reproducibility, and recovery for the method. We also validated the method using whole blood of F344 rats dosed with a single dose of AFB_1 at 0, 25, 75, 225, or 675 µg/kg body weight and obtained linear correlation for the method. In addition, we analyzed AFB-lysine adduct for serum samples collected from East Timor and Kenya human population studies conducted by our collaborators.

Capacity Building

None to report.

Lessons Learned

Although similar limit of detection of AFB-lysine adduct was achieved with the DBS cards, the recovery of the method for the whole blood DBS was generally lower (10-20%) than the serum method, which suggested that certain components in the whole blood may be interfering with the recovery.

Presentations and Publications

In addition to two presentations in PMIL PI meetings, three seminar presentations were given to different audience: the first was given in Uganda in December 2013, the second in the Society of Toxicology Annual Meeting held in Phoenix, Arizona, March 2014 and the third in the International Mycotoxin Conference held in Beijing, China, May 2014.

Project B3. Randomized Controlled Trial of the Impact of Treating Moderately Malnourished Women in Pregnancy

Women being interviewed for nutrition study in Malawi. Photo courtesy of Mark Manary.

The objective of this project is to determine the benefits of treating moderately malnourished pregnant women with a peanut butter-based nutritional supplement. The trial is a randomized, investigator-blinded controlled clinical effectiveness trial in pregnant women with moderate malnutrition, with and without HIV-infection, in southern Malawi. The trial is using three different nutritional supplements for comparison: 1) a Ready-to-Use Supplementary Food (RUSF) formulated to deliver about 200% of the RDA of most micronutrients in pregnancy (RUSF-P); 2) fortified corn soy blend (also known as CSB+ or super-cereal) with a multiple micronutrient tablet chosen to deliver about 200% of the RDA of most micronutrients (CSB-P); or 3) the standard of care which is a fortified corn soy blend, vegetable oil and sugar with supplementary iron and folic acid tablets (CSB), delivering between 0-350% of the RDA. The primary outcomes for this study are both maternal; recovery and MUAC change, as well as infant outcomes in mean birth weight, mean birth length, and percentage of premature delivery. The aim of the study is to provide significant evidence that using a peanut -based supplementary food will reduce maternal mortality and improve infant growth and development. This will provide national and international agencies with evidence to recommend and promote the use of peanut-based products for maternal health, as well as purchase some for use in their nutrition programs.

Collaborators

Name	Institution	Country	Role
Mark Manary	Washington University	USA	PI
Ken Maleta	University of Malawi	Malawi	Co-PI
Chrissie Thakwalakwa	University of Malawi	Malawi	Co-PI
Peggy Papathakis	California Polytechnic State University	USA	Co-PI

Achievements

The study just recently began enrolling participants in March 2014 as a result there is not significant achievement to speak of at this time. Enrollment, however, has been steadily increasing. As of mid-July, 2014 there are 6 study sites open in rural Malawi being overseen by study volunteers and health clinic staff. A total of 170 study participants have been enrolled and are reporting bi-weekly for follow-up. Of the total participants that have been enrolled 40 have graduated the program (recovered before delivered). In addition 88 participants have delivered and will continue to follow up bi-weekly until three months post-delivery. The study has also begun conducting home visits to collect adherence information, household food inventory and to obtain a 24hr dietary recall. The research team hopes to continue to expand to more sites and enroll more participants. The team is aiming to have four more study sites running and the sub study looking at vitamin and mineral status in September 2014

Capacity Building

Awareness of the problem of malnutrition during pregnancy was raised at the district and national levels in Malawi through this project. Fifty-five local health care staff were trained and are now screening pregnant women for malnutrition, and referring those they find to the feeding study. The research project developed a local management protocol that is under consideration for district wide adoption. Over 400 smallholder farmers were trained in post-harvest handling of peanuts to minimize aflatoxin contamination.

Lessons Learned

The study has faced some obstacles over the past few months; the team has been perseverant in carrying out the trial's objectives. The resilience of volunteers and health clinic staff in facing these obstacles is noteworthy. Study participants are very generous with their time and doing their best to work with the study design.

Presentations and Publications

None to report.

C. Peanut Value Chain Interventions

Project C1. Production to Consumption – Technologies to Improve Peanut Production, Processing and Utilization in Haiti

The overall goal of this project is to address and mitigate key constraints to peanut production and utilization in Haiti. Peanuts have been and continue to be an important part of Haitian diet and culture. In addition, peanuts provide an important source of cash income. To combat malnutrition in the country, certain NGOs have developed facilities to produce peanut-based 'Ready-to-Use Therapeutic Food, RUTF'. To date, however, there has been limited utilization of locally grown peanut due to issues with productivity, quality and aflatoxin contamination. In 2007, Peanut CRSP (under project UFL 155) worked with Meds & Food for Kids (an NGO based in Cap Haitian) to help improve peanut production. Our project quickly realized peanut production in Haiti could immediately benefit from a wider choice of technologies, which were just recently becoming available through the work of the Peanut CRSP and their Haitian partners. While our project provided some initial gains, peanut diseases such as rust, variety performance as it relates to yield and quality, harvest efficiency, storage, aflatoxin and marketing

Former President Bill Clinton and Frank Guistra cut the ribbon at the opening of the new Acceso Depot in Haiti, June 2014. Photo courtesy of Christy Fricks.

remain as critical factors limiting productivity and utilization of peanut in Haiti. Aflatoxin contamination remains a barrier to export markets and a threat to the health of local consumers and producers and diverting contaminated peanuts to non-food uses is critical to the health of local populations who might otherwise eat rejected peanuts. Assessments of how value-added markets have influenced the local and regional economy, especially as it relates to women, have not been thoroughly studied.

We are developing a comprehensive production, processing and utilization strategy for peanuts in Haiti. We began by establishing a research farm with a local landowner, providing infrastructure improvements to modernize production facilities. Demonstration is a key component of the farm, and the development of a cooperative is one of the major goals of the landowner. All phases of peanut production will be evaluated, including varieties specific to the region and market influences. We will institute a seed-increase program and develop facilities to maintain genetic resources through curation of important peanut germplasm. Capacity building through the introduction of labor saving devices and harvesting equipment and procedures will be accomplished, along with infrastructure to improve peanut handling, drying and long-term storage. Once these improvements have been evaluated, we will take these best management practices and strategies to the grower level at several villages and communities in the region, particularly through the depot network partnership with the Acceso Peanut Corporation. We will provide training and infrastructure support to realize these improvements and ensure long-term capacity building. Aflatoxin and the role of women in the peanut value chain will be measure/surveyed throughout the duration and in all phases of the project. We will re-establish aflatoxin testing facilities and re-train Haitians in how to measure and the importance of avoiding aflatoxin in their diet. Another important capacity building measure will be the creation of alternative products/markets for high aflatoxin contaminated peanuts.

Collaborators

Name	Institution	Country	Role
Greg MacDonald	University of Florida	USA	PI
Timothy Brenneman	University of Georgia	USA	Co-PI
Dan Brown	Cornell University	USA	Co-PI
Robert Kemerait	University of Georgia	USA	Co-PI
Genti Kostandini	University of Georgia	USA	Co-PI
Robert Johnson	Acesso Peanut Enterprise Corporation	Haiti	Partner
Dominique LaForest	Meds & Food for Kids	Haiti	Partner
Francois Laroche	Kreyol Incorporated	Haiti	Partner
Noelle Barkley	USDA-ARS	USA	Partner
Rick Brandenburg	North Carolina State University	USA	Partner
David Jordan	North Carolina State University	USA	Partner
Frank Nolin	Frank's Design for Peanuts	USA	Partner
Rajapopalbabu Srinivasan	University of Georgia	USA	Partner
Barry Tillman	University of Florida	USA	Partner
Patricia Wolff	Meds & Food for Kids	USA	Partner

Achievements

- Conducted trials on fertility, disease management with fungicides and variety evaluations at two locations (Quartier Morin, North Haiti and Zanmi Agrikol, Central Haiti)
- Conducted additional trials at Quartier Morin on vermicomposting and biochar
- Performed seed increase of promising variety with Kreyol, Inc. and iF Foundation
- Provided training and farmer field demonstrations in North, Northeast and Central Plateau
- Provided technical training, materials and support to Acesso Peanut Enterprise Corporation
  - Production guides
  - Field visits
  - Aflatoxin training for depot managers
  - Technical expertise in planting, harvesting, storage and aflatoxin detection
- Provided guidance and expertise to Meds & Food for Kids agronomists
- Established an aflatoxin detection facility at iF Foundation, provided training of staff to operate and maintain
- Initiated baseline livelihood surveys of intervention areas

Capacity Building

- Training and aflatoxin lab establishment, research trial locations at Meds & Food for Kids, Zanmi Agikol and Kreol, Inc.
- Associated training with above facilities

Lessons Learned

Oversight is critical with field operations, especially research field locations.

Presentations and Publications

None to date, will be working on updates for production guides and for aflatoxin.

Project C2. Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana

Farmers evaluate new peanut varieties at a field site in Ghana. Photo courtesy of David Jordan.

A wide range of abiotic and biotic stresses negatively impact peanut production in the field and generally contribute to reduced quality of marketed peanut in Ghana and West Africa. Aflatoxin, produced by *Aspergillus flavus*, negatively impacts health when humans and livestock consume contaminated products. Aflatoxin contamination can occur and increase at all steps of the peanut supply chain including production in the field, storage in fields and villages, and in processed products. Interventions at each step of the supply chain can minimize aflatoxin contamination. Improved production in the field including pest resistant cultivars, adequate soil fertility and plant nutrition, and synchronization of peanut pod growth phase with adequate soil moisture can increase peanut yield and quality and minimize aflatoxin contamination. Adequate and timely drying of farmer stock peanut minimizes

additional production of aflatoxin during storage in villages prior to marketing. Effective processing of farmer stock and shelled stock peanut can also reduce aflatoxin prior to purchase and consumption. Strategies that mitigate aflatoxin are not employed sufficiently in rural areas of Ghana. Determining current practices by farmers, conducting research to mitigate aflatoxin and improve peanut quality, and transferring appropriate technology to farmers are needed to improve productivity, profits, and quality of peanut and to increase safety of peanut products consumed by humans and livestock.

The primary platform for addressing aflatoxin contamination of peanut in the supply chain in Ghana will be activities at nine villages in northern and central Ghana. Interventions at each step of the supply chain will be implemented and aflatoxin contamination determined. Research will be conducted at two institutions associated with the Savanna Agricultural Research Institute (SARI) and at the Crops Research Institute (CRI) to develop appropriate production and pest management strategies and evaluate new germplasm suitable for the region. Results from efforts at villages and research stations will be presented to farmers using the Farmer Field School approach and appropriate posters, bulletins and manuals. Graduate student training will be linked closely to activities in villages and research stations.

Results from the project will provide farmers in Ghana with information on documented interventions that reduce aflatoxin contamination of peanut throughout the supply chain. Improved productivity and quality of peanut coupled with acceptable levels of aflatoxin in peanut products will improve access to local, regional, national and international markets leading to enhanced economic viability of farmers and their communities.

Collaborators

Name	Institution	Country	Role
David Jordan	North Carolina State University	USA	PI
Mumuni Abudulai	CSIR-Savanna Agricultural Research Institute	Ghana	Co-PI
Richard Akromah	Kwame Nkrumah University of Science and Technology	Ghana	Co-PI
Grace Bolfrey-Arku	CSIR-Crops Research Institute	Ghana	Co-PI
William Ellis	Kwame Nkrumah University of Science and Technology	Ghana	Co-PI
Moses Mochiah	CSIR-Crops Research Institute	Ghana	Co-PI
Jessie Naab	CSIR-Savanna Agricultural Research Institute	Ghana	Co-PI
Maria Balota	Virginia Polytechnic Institute and State University	USA	Co-PI
Rick Brandenburg	North Carolina State University	USA	Co-PI
Boris Bravo-Ureta	University of Connecticut	USA	Co-PI
Kenneth Boote	University of Florida	USA	Co-PI
Jinru Chen	University of Georgia	USA	Co-PI
Greg MacDonald	University of Florida	USA	Co-PI
Kumar Mallikarjunan	Virginia Polytechnic Institute and State University	USA	Co-PI
Robert Phillips	University of Georgia	USA	Co-PI
James Asibuo	CSIR-Crops Research Institute	Ghana	Partner
Agnes Budu	University of Ghana	Ghana	Partner
Awere Dankyi	CSIR-Crops Research Institute	Ghana	Partner
Tim Brenneman	University of Georgia	USA	Partner
Manjeet Chinnan	University of Georgia	USA	Partner

Achievements

Thirty participants met in Kumasi, Ghana at KNUST during January 27-29, 2014 to address specific aspects associated with the project. Despite the delays with issuing contracts, activities have been initiated as follows.

To monitor aflatoxin contamination in the supply chain and compare interventions at production, drying, storage and processing steps to reduce contamination, agreements with farmers in five villages in Ghana (Kpongu, Sillbelle-Sorbelle and Tamale in northern Ghana and Drobonso and Ejura in central Ghana near Kumasi) with 8-10 farmers in each village were established in May with in-field practices of early versus late plantings (early May and late June, respectively) of the locally-grown variety (SARI, three villages) or early season versus late season (early May and late July) of the locally-grown variety Chinese (CRI, two villages) initiated. Groundnut harvest will begin in September 2014 with drying and storing treatments imposed immediately after harvest.

Most of the small-plot experiments planned for 2013-14 were not established during this fiscal year and will be initiated in 2014-15 as components of graduate studies. However, one test is being conducted at SARI and CRI to compare three drying techniques (standard drying in the field, drying on tarps, and drying in A-frame structures. This test will be established in October 2014 following harvest in the late season in Kumasi and the latter planting date at Tamale.

Two trials at CRI and SARI were established in May-July 2014 and included sixteen ICRISAT lines and six promising lines from Ghana. Data will be reported in November after harvesting and processing samples.

Capacity Building

Three Ghana nationals (Stephen Arthur, Yussif Abubakari, Isaac Addo) have been enrolled at KNUST in the following three subject matter areas: a) agronomy and pest management, b) agricultural engineering (postharvest handling and storage), and c) food science (processing) with a core focus on aflatoxin mitigation. Two female students (Esther Akoto, Samira Mohammed) are now enrolled at the University of Georgia and will begin their programs in August 2014.

Lessons Learned

Under-estimated the time and effort required to develop the final project proposal and establish all sub-awards necessary.

Presentations and Publications

A production guide entitled *Integrated Practices to Manage Diseases, Nematodes, Weeds and Arthropod Pests in Ghana* (Owusu-Akyaw, Mochiah, Gyasi-Boakye, and Asafu-Agyei, editors) was completed and printed in Ghana and distributed to MOFA, NCSU, CRI, SARI, KNUST, UDS, and contributing scientists. Over the period of the current project an updated guide will be printed to include mycotoxin management.

Project C3. Producer and Consumer Interventions to Decrease Peanut Mycotoxin Risk in Ghana

The goal of this project is to investigate the relative and combined impact of technological and market aflatoxin mitigation interventions for groundnuts. The technological intervention will facilitate the adoption of simple and low-cost aflatoxin prevention technologies. Essentially, we plan to give a randomly selected subset of study farmers the materials and information necessary to adopt. We will

Women shell peanuts in Ghana. Photo courtesy of Nick Magnan.

work with local experts to identify the preventative measures with the best potential to long-term and affordable solutions. The market intervention will ensure a premium for a different and partially overlapping randomly selected subset of study farmers. To do this we will work with local groundnut buyers to offer a premium for groundnuts tested by the project that pass a safety criterion. Producers selected to receive the market intervention will be aware of whom they can sell safe groundnuts to, and what the standards are to qualify for the price premium.

In Ghana, women constitute over 48% of the agricultural labor force. Furthermore, women are the main purchasers of groundnuts, who then used them to make paste and extract oil. Hence, when designing the questionnaires and intervention we will consider gender differences. We will build in modules on gender, individual assets and joint asset ownership at baseline. In this way we will attempt to capture the gender dynamic around reasons why/why not individuals/household adopt control measures.

Collaborators

Name	Institution	Country	Role
Nicholas Magnan	University of Georgia	USA	PI
Gissele Gajate-Garrido	International Food Policy Research Institute	USA	Co-PI
Vivian Hoffmann	International Food Policy Research Institute	USA	Co-PI
Grace Motey	University for Development Studies	Ghana	Partner
Nelson Opoko	University for Development Studies	Ghana	Partner

Achievements

To date, we worked with 40 farmers in the Northern and Upper East regions of Ghana to pilot two alternative drying practices and two alternative storage practices in various combinations compared to their status quo practices. We collected groundnut samples for each at the time of harvest and will test these samples for aflatoxin. In November-December 2015 we will collect more samples after 2 months of storage to see which combination of technologies is most effective. We will use that combination for our larger study, rolling out the technology package in June 2015. We have also begun collecting data on groundnut marketing in 20 villages in the Northern and Upper East region to help us devise the market intervention.

Capacity Building

To date, capacity building has included training the 40 pilot farmers on post-harvest aflatoxin prevention. We have also trained two University of Development Studies graduate students and one Ministry of Agriculture extension agent on these practices.

Lessons Learned

We have learned that post-harvest practices vary substantially based on farm size and labor constraints, and that these two factors vary more by village and district rather than by farmer. Best post-harvest practices therefore are likely highly location specific.

Presentations and Publications

As the project is early on, we have not collected sufficient data to conduct analysis. We expect to be able to write a paper or brief on the results of the pilot study in December 2015-January 2016.

Project C4. Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia

Dave Hoisington and David Okello meet with farmers in Uganda. Photo courtesy of David Okello.

This project will address a wide range of production, post-harvest handling, and processing issues relative to peanuts in Malawi, Zambia and Mozambique that can impact aflatoxin contamination levels, yield and profitability. The strength of this project is that interventions will be studied throughout the value chain and the cumulative effect of these efforts measured against traditional production and marketing practices. Through linkages with various partners, farmer education will be emphasized and extended linkages with various industries and marketing groups will help accelerate aflatoxin mitigation and market development.

Malawi has a strong history of research on peanut through ICRISAT, the Department of Agriculture Research at Chitedze Research Station, and Lilongwe University of Agriculture and Natural Resources (LUANAR), but the ability of farmers to produce high yielding, high quality peanuts with consistently low aflatoxin levels is still quite limited. Additional agencies such as NASFAM (National Small Farmer Association of Malawi), the Ministry of Agriculture, Exagris, Afri-Nut, TWIN of the U.K., the Clinton Development Initiative and others are all engaged in further evaluation of production, processing, and marketing strategies as well as farmer education. Improved cultivars are available, but the lack of an effective seed program limits availability. Limited marketing due to high aflatoxin contamination levels exacerbates the problem by reducing farmer incentive to implement current production recommendations and limits commercial processing and marketing.

Our project, with its multidisciplinary team, takes a comprehensive approach to problem solving research and effective technology transfer through key partnerships with in-country research counterparts and NGOs. The higher level of peanut research in Malawi will be expanded and emphasis placed on implementation and additional research efforts will be rapidly phased in to Zambia and Mozambique creating a regional project providing research data with even wider scale application. Key components will include taking advantage of improved germplasm already available, in-country aflatoxin testing equipment and technicians already in place, key production, processing, marketing and technology transfer partners. Our project will address the challenges from production to processing including information transfer and aflatoxin awareness creation along the whole value chain. The project will use the unique and innovative approach known as PIIM (Peanut Industry Incubator Model) to fast track the food process and product development cycle ensuring safe (aflatoxin free and microbiologically safe) and nutritious peanut based products. This model has been successfully implemented in other countries through USAID Peanut collaborative projects in the Philippines, Thailand, Uganda and Ghana. The critical step in the PIIM approach is early engagement of small or medium scale private seed and food processors (FP) with the researchers. . In addition, this approach will assess the need for development of good manufacturing practices such as HACCP and facilitate the development of value added peanut based products that will increase the livelihood of farmers and industries.

Collaborators

Name	Institution	Country	Role
Rick Brandenburg	North Carolina State University	USA	PI
Justus Chintu	Chitedze Agriculture Research Station	Malawi	Co-PI
Trust Donga	Lilongwe University of Agriculture and Natural Resources	Malawi	Co-PI
Agnes Mwangwela	Lilongwe University of Agriculture and Natural Resources	Malawi	Co-PI
Samuel Njoroge	ICRISAT	Malawi	Co-PI
Amade Muitia	Instituto de investigação Agrária de Moçambique	Mozambique	Co-PI
Alice Mweetwa	University of Zambia	Zambia	
John Shindano	University of Zambia	Zambia	Co-PI
Manjeet Chinnan	University of Georgia	USA	Co-PI
David Jordan	North Carolina State University	USA	Co-PI
Kumar Mallikarjunan	Virginia Polytechnic Institute and State University	USA	Co-PI
Wojciech Florkowski	University of Georgia	USA	Co-PI
Andrew Emmott	TWIN Trading Ltd.	Malawi	Partner
Jim Goodman	Exagris Africa Ltd.	Malawi	Partner

Achievements

The start of this project was significantly delayed due to the process of assembling the necessary team to address the value chain, philosophical differences among team members for the project's focus, and time to develop the necessary sub-awards. The effort to assemble the team and agree on objectives was not successful in 2013, thus a meeting was held on January 23 and 24, 2014 in Lilongwe, Malawi attended by representatives from the University of Georgia, Virginia Tech, North Carolina State, USAID, PMIL ME, University of Zambia, ICRISAT in Malawi and Kenya, LUANAR, TWIN, and other organizations. The intent of this meeting was to pull scientists together into a cohesive unit and finalize objectives, work plans, and budgets. This was not accomplished during this meeting and a new plan with several new scientists was embraced and moved forward. As a result the socioeconomics portion was withdrawn from this project and is being developed independently. Additional trips were made to Mozambique in April 2014 and LUANAR (Lilongwe University of Agriculture and Natural Resources) and University of Zambia. The contract was finally signed in August 2014 and fund transfers began in September 2014. The results of these delays minimized the actual research that was initiated during the first year of the project. Activities that were pursued are outlined in this report.

A major objective of the project is to evaluate the impact of reducing plant of pest stresses on *Aspergillus* infection and contamination. This involved evaluating cultural practices including rotation and harvest dates (maturity) with multiple cultivars on termite infestations, plant pathogens and aflatoxin levels. Additionally, drying techniques and storage insect pests and relationship to aflatoxin contamination are being investigated. The crop rotation study and the biotic stress studies are assigned to LUANAR in Lilongwe, Malawi and the process to recruit two MSc students is underway. Students will be coordinated by LUANAR faculty with oversight from Dr. Samuel Njoroge from ICRISAT-Malawi. A third study on soil amendments will be conducted at the University of Zambia and directed by Dr. Alice Mweetwa. An MSc student initiated coursework relative to this project in 2014 and the research location (both field and greenhouse) will be in Zambia (UNZA in Lusaka and Msekera in Chipata district).

Varieties, production practices and pest management concepts developed at ICRISAT-Malawi are being evaluated in Zambia and Mozambique. The efforts are directed by Dr. Njoroge at ICRISAT and within country by Dr. Alice Mweetwa at the University of Zambia and Amade Muitia from IIAM.

A PhD student has initiated coursework at UNZA, Zambia and been assigned to develop risk indices based on soil characteristics, crop rotations, weather patterns, cultivars, and planting and harvest dates into a risk index to forecast aflatoxin incidence (based loosely on the Auburn University model for peanuts). These studies will be located in Zambia (UNZA in Lusaka and Masumba station in Mambwe district) and Malawi (Chitedze Research Station in Lilongwe). Lab work will include analysis of samples for aflatoxin contamination, enumeration and identification of *Aspergillus* species and be conducted at ICRISAT (Chitedze).

Dr. Wellam Kamthunzi from the LUANAR and Dr. Isaac N. Samate of the University of Zambia are initiating research to develop country specific, appropriate and affordable drying (Mandela cork, drying racks, etc.) and storage practices (in drums, poly bags, etc.) to reduce incidence of mold growth on raw peanuts.

The objective to develop and transfer appropriate processing technologies to mitigate aflatoxin in the final peanut-based products was initiated during the June 2014 visit of Dr. Chinnan to Malawi. Dr. Agnes Mwangwela will further follow up with identifying more individuals or entrepreneurs in Year 2. Dr. Wellam Kamthunzi has been identified to work on the mechanical sorting activity.

Capacity Building

MSc and PhD students have been appointed as indicated above.

Lessons Learned

Under-estimated the time and effort required to develop the final proposal for such an extension and complex project. Combined with the time to establish the necessary sub-awards led to a much-delayed start to the project. All is in place now and concerted efforts are being taken to accelerate the activities so that the overall objectives will be met as originally planned.

Presentations and Publications

None to report.

Associate Award Research Project Reports

No Associate Awards have been received to date.

Human and Institutional Capacity Development

Short-Term (by country)

Name	Gender	Country	Home Institution	Research Focus	Training Institution
Abdi Hassen	M	Ethiopia	Hawassa University, Awassa, Ethiopia	Detection of aflatoxin types and molecular diversity of *Aspergillus* species from Ethiopia	USDA-ARS National Peanut Research Lab, Dawson, GA, USA

Long-Term (by country)

Name	Gender	Country	Degree	Discipline	Research Focus	Training Institution
Abubakari Yussif	M	Ghana	MPhil	Food Science and Technology	Assessment of aflatoxin in northern Ghana	Kwame Nkrumah University of Science and Technology
Esther Yeboah Akota	F	Ghana	MSc	Food Science		University of Georgia
Isaac Kwesi Addo	M	Ghana	MSc	Food & Postharvest Engineering	Design and evaluation of dryers for peanuts	Kwame Nkrumah University of Science and Technology
Stephan Arthur	M	Ghana	MPhil	Agronomy	Assessment of weed management on peanut production in Ghana	Kwame Nkrumah University of Science and Technology
William Ofori Appaw	M	Ghana	MPhil	Food Science and Technology	Mitigation of aflatoxin along peanut value chain in Ghana	Kwame Nkrumah University of Science and Technology
Andrew Abraham	M	Malawi	MSc	Crop Science	Effect of crop rotation and harvest date on aflatoxin	Lilongwe University of Agriculture and Natural Resources
Chancy Bahat Sibakwe	M	Malawi	MSc	Entomology	Identification of biotic and abiotic stress tolerance in peanut	Lilongwe University of Agriculture and Natural Resources
Munsanda Mgulube	M	Malawi	MSc		Analysis of peanut value chain in Malawi	Lilongwe University of Agriculture and Natural Resources
Hendrix Chalwe	M	Zambia	PhD		Study of peanut value chain interventions in Zambia	University of Zambia

Institutional Development

Two greenhouses were renovated at the National Semi Arid Resources Research Institute (NaSARRI) station in Uganda to improve breeding conditions.

Non-profit aflatoxin testing facilities were established at the iF Foundation laboratory in Haiti.

Technology Transfer and Scaling Partnerships

Since this is still the early phase of the project, most technologies are also in the early phases of development and evaluation. Each project has also developed the groundwork for adoption and scaling of technologies through appropriate partnerships.

Single/Partial Kernel Aflatoxin Detection

The USDA-ARS Peanut lab in Dawson was able to develop an Ultra-High Pressure Liquid Chromatography (UHPLC) method for quantification of aflatoxin in single or partial kernels. This is an essential lab technique for improved evaluation of aflatoxin resistant variety development and can be shared with collaborating labs.

Variety Development

Development and adoption of peanut varieties requires a systematic pipeline from breeder to grower that includes commercialization of seed multiplication. Due to high seeding rates, relatively low seed yield and traditional practice of self-saved seed, commercialization of peanut seed has proven difficult in the smallholder setting. However, variety development with traits such as disease resistance or drought tolerance has the highest likelihood of improving farmer livelihoods of most any agronomic interventions.

In Uganda, several varieties with desirable traits such as resistance to groundnut rosette disease and high oleic acid ratio have been evaluated in several contexts and released for farmer adoption (e.g., Serenut 5R and 6T). Even more importantly, networks of seed producers are engaged in commercialization of these varieties through the Local Seed Business Groups of the Integrated Seed Sector Development project.

In Haiti, ongoing evaluations in multiple locations have yielded some potential varieties for commercialization and relationships with the Acceso Peanut Corp and collaborating partners Kreyol, Inc. and the iF Foundation have been established and tested to quickly scale varieties as they are identified.

Governance and Management

Management Entity

The Peanut & Mycotoxin Innovation Lab (PMIL) Management Entity is housed in the Office of Global Programs at the University of Georgia College of Agricultural and Environmental Sciences, Athens Georgia. The University of Georgia is the Prime Contractor of the PMIL award.

The Management Entity is composed of the following staff:

- Dave Hoisington, Director
- Jamie Rhoads, Assistant Director
- Allen Stripling, Business Manager
- Christy Fricks, Communications Specialist
- Michelle McGeehan, Web Developer
- Bonnie Klostermann, Administrative Specialist

The Director and Assistant Director hold Research Faculty positions in the Crop and Soil Sciences Department. The Web Developer is a member of the Office of Information Technology, and the Administrative Specialist is a shared position with the Office of Global Programs.

The team is further supported by other departments, especially the Office of Sponsored Programs and the Contracts and Grants Division, within the University.

External Advisory Committee

The PMIL External Advisory Panel (EAP) is responsible for unbiased advice on technical matters within our portfolio of projects. The team of independent experts helps the PMIL Director and USAID by identifying opportunities for partnerships, research portfolio gaps and solutions, and suggesting ideas for promoting the PMIL program goals. The EAP meets physically at least once each year, normally at the PMIL Annual Research Meeting, and at least one other time virtually. Many of the EAP participate in visits to PMIL research sites in the various countries.

Current EAP members are:

- Martha Byanyima, SPS and Agribusiness Expert, Common Market for Eastern and Southern Africa (COMESA), Uganda
- Kitty Cardwell, National Program Leader, United States Department of Agriculture (USDA), USA
- Jeff Ehlers, Program Officer, Bill & Melinda Gates Foundation, USA
- Andrew Emmott, Senior Associate, Twin and Twin Trading Ltd., UK
- Jeff Johnson, President, Birdsong Peanuts, USA
- Jennifer Long, Senior International Agricultural Research Advisor, USAID Bureau for Food Security, USA
- John McDermott, Director, CGIAR Research Program on Agriculture for Nutrition and Health, USA
- Isaac Minde, Deputy Director, Innovative Agricultural Research Initiative (iAGRI), Tanzania and Professor of International Development, Michigan State University, USA
- Shyam Nigam, Expert Consultant in Agriculture for Development, India
- David Wright, Extension Specialist and Professor of Agronomy, University of Florida, USA

Program Research Meetings

PMIL Management Team, External Advisory Panel, USAID, Principal Investigators and Country Collaborators meet to discuss research progress at Rock Eagle Center, USA. Photo courtesy of Christy Fricks.

PMIL conducted two program-wide research meetings during the year to discuss research progress and plans. The first was conducted in November of 2013 and involved the Principal Investigators of the approved PMIL projects, the Management Team and USAID AOR. As most projects were just approved, the meetings provided a good opportunity to discuss how to best coordinate research across PMIL.

The second meeting took place in July of 2014, and most all PIs, Management Team, External Advisory Panel, USAID and country scientists participated. Project updates were presented and discussed by all participants. The External Advisory Panel also met and made recommendations on ways to enhance cooperation and better focus the research across PMIL. Specifically, the EAP recommended to accelerate activities especially in the target countries, better articulate the vision of the program to improve peanut production and consumption, consider key elements required to achieve change, and strengthen attention to gender considerations throughout the research.

A significant output from the meeting was an agreement to strengthened efforts in addressing mycotoxin contamination, especially in dealing with sampling variability. Following the meeting, a few of the Management Team, External Advisory Panel and country scientists visited research sites and institutions in Georgia.

Several other meetings were conducted during the year in addition to the two program-wide meetings. One was a meeting at the Plant and Animal Genome Conference in January 2014 with representatives of the Bill & Melinda Gates Foundation to discuss joint research in peanut genomics and breeding. Outcomes from the meeting include the involvement of PMIL in the formulation of the Bill & Melinda Gates Foundation Tropical Legumes III project.

Project planning meetings in January 2014 in Malawi for the Southern Africa Peanut Value Chain Project and in Ghana for the Ghana Peanut Value Chain Project resulted in the approval of the revised project proposals for each region and the issuance of sub-awards to North Carolina State University for implementing the projects.

During the American Peanut Research and Extension Society annual meeting in July 2014, PMIL organized a session to discuss research activities with those in attendance at the meeting. Discussions were also held with the incoming President of APRES to organize a session at the next meeting that would focus on international efforts in peanut research including those conducted by PMIL.

PMIL research was featured as part of the 'Hot Topics' organized during the Georgia Peanut Tour in September 2014. Presentations by the PMIL Assistant Director and other PMIL scientists provided an opportunity to inform the tour participants about the Feed the Future and PMIL programs.

Project Monitoring and Evaluation

PMIL scientists discussing peanut research at the National Peanut Research Lab, Dawson, GA. Photo courtesy of Dave Hoisington.

In April 2014, the Director visited IIAM in Nampula, Mozambique to meet with PMIL partners located there and to discuss proposed project activities. Visits to the IIAM research station, IKURU farmer cooperative and Lurio University provide opportunities to discuss areas for collaboration.

Also in June during a visit to Uganda, the Director visited with the Acting Director of NARO and the NaSARRI research station near Serere. While in the Serere region, discussions with local farmers producing peanut seed for local sale provided more details regarding opportunities to address local needs. In the farmers' market in Kampala, the Director interacted with several women producing peanut paste from locally and regionally sourced peanuts. Finally, a meeting with Bugusu Women's Group identified new opportunities to evaluate new peanut varieties produced by the national program.

The Director, Assistant Director and Communication Specialist participated in the launching of the Clinton-Guistra Acceso Depots in June 2014 in the Central Plateau in Haiti. PMIL was asked to participate at the request of the Acceso Corporation in recognition of the backstopping efforts PMIL, and the previous Peanut CRSP, provided to the partners in Haiti. Following the event, the PMIL staff visited the Meds & Food for Kids RUTF factory, farmers and other partners in the Cap Haitian region. A visit with USAID in Port-au-Prince provided an opportunity to update the mission on PMIL activities in the country and to discuss issues related to mycotoxin control in a range of commodities.

During the year, several visits by members of the Management Entity were made to PMIL research sites in Georgia, Missouri and North Carolina to discuss research progress.

Finally, members of the Management Entity participated in the USAID Innovation Lab Council meetings in March 2014 in Nepal and September 2014 in Washington, DC during the year.

Communications

In the short nine months since establishing a communications position, the visibility of the Feed the Future Peanut & Mycotoxin Innovation Lab mission has increased dramatically. Local and national media have featured the work of our scientists and collaborators. Our communications efforts have been noted by numerous individuals and organizations most notably, the President of The University of Georgia. We currently post news, photos and information relevant to our PMIL mission numerous times a week. Highlights from the year include the following.

- Established branding and logo guidelines in accordance with USAID.
- Crafted overall communications strategy to raise awareness of PMIL goals locally, nationally and regionally.
- Designed new PMIL logo in accordance with USAID and UGA policies.
- Crafted and began media outreach strategy.
- Crafted main messages for use in publicity materials.

- Wrote and created new updated web content and assisted with design.
- Established database of promotional photos.
- Created web and social media banners.
- Designed and wrote content for print media: two new PMIL posters, informational brochure and pop-up banner.
- Began publishing monthly e-Newsletter.
- Established and populated social media: Facebook (200+ members), Flickr (30+ followers), Twitter (over 204 posts and 92 followers) and LinkedIn.
- Established a core Twitter list feed to link all Feed the Future Innovation Labs on Twitter.
- Posted over 200 pages of content on new PMIL blog.
- Published several feature articles that were reprinted in both state and national media.
- Established a listserv for communications personnel at other FTF Innovation Labs.
- Published two articles in the USAID Feed the Future Newsletter and worked to strengthen media relations with the main FTF communications team.

PMIL Twitter page grows to over 100 followers in a few short months.

Information Technology

In the past year we have moved the Peanut & Mycotoxin Innovation Lab Information Technology services from a stand-alone single person managed system, to the University of Georgia's College of Agricultural & Environmental Sciences enterprise system. The benefits of this transition at no cost to PMIL include the following.

- Helpline and support staff for desktop support issues, including a GoToMeeting subscription.
- Servers, long term data storage, firewalls, remote site nightly back up, end of life equipment replacement, and System Administration staffing.
- Adobe Experience Manager Website Content Management System in development for fall/winter release including web design and development support staff.
- WordPress blog design and support staff.

PMIL develops new website within the University of Georgia College of Agricultural and Environmental Sciences.

Having the enterprise system and staffing in place has allowed us to focus on frontend web design and data management, including the following.

- Rebuilt website from its foundation with audience focus from the average person to the scientific community, using web design core messaging and principles.
- Worked with Office of Information Technology to follow pre-existing web design standards incorporating PMIL content into their existing system as a staging ground for the website while we wait for the new website Content Management System to be deployed.

- Created all website content during website rebuild, and content as needed going forward.
- Added social media content to website as Twitter, Facebook and Flickr accounts were created.
- Moved PMIL data to a secure server within a datacenter that is behind a firewall, backed up nightly, and backed up in a remote location.
- Working to consolidate all PCRSP/PMIL data onto a single enterprise server.
- Set up WordPress blog instance for PMIL communications to submit posts.
- Set up Mail Chimp HTML newsletter instance and distribution lists for PMIL Communications Specialist to distribute newsletters.
- WordPress blog and Mail Chimp HTML newsletter instances are connected via RSS feed for automated population of newsletter content from blog.
- Setup and maintenance of Copper Project web based Project Management Software for use by Scientists as a task and data management system to submit data to the Management Entity.

We also worked to improve international collaboration through video conferencing by installing video conferencing equipment in the meeting rooms in the building where the Management Entity is located.

Other Topics

In addition to the research outlined above, efforts are underway to link with the CGIAR's Research Program (CRP) on Grain Legumes hosted at ICRISAT in India. As peanut is one of the commodities being researched in the CRP, links with this program will enhance efforts in those countries where both programs are working, especially in Africa. To better identify linkages, the PMIL Director has been appointed the member of the Research Management Team of the CRP and was able to attend several of the research meetings held during the year.

As data management is an important component for success in PMIL, the program is linking with the CGIAR's Generation Challenge Program's Integrated Breeding Platform initiative. The program has developed a software platform that integrates many of the tools necessary for modern information-based breeding. PMIL plans to use the Integrated Breeding Platform as one of its breeding tools and will be conducting training sessions during FY2015 in the USA and many of its partner countries. The adoption of such a platform not only will improve breeding efficiencies, it will also provide an effective method of addressing the new Open Data Policy of the US Government.

Issues

No major issues have arisen during the past year. Certain unanticipated administrative issues in signing the sub-award contracts for some of the projects did result in delays in these projects, but all approved project contracts were signed by the end of FY2014 and efforts are now underway to accelerate the research activities. The Management Team is working closely with the respective Principal Investigators to identify mechanisms to ensure that the planned outputs will be produce according to the original timeline.

Future Directions

The next fiscal year will see a continuation of the on-going research activities across the PMIL projects. The first results from the on-station and on-farm trials of value chain interventions and varietal tests will be obtained, leading to plans for further tests and ultimately scaling up and out of the best technologies.

The adoption of new data management technologies such as the IBP will be encouraged across the PMIL breeding and genomics projects, both in the USA and partner countries. Beyond breeding, data management will be further strengthened in all PMIL projects during the year to address the new data requirements.

During FY2014, it became apparent that more focus on mycotoxin sampling strategies is required, and efforts were initiated at the end of FY2014. These will be enhanced during FY2015 leading to a proposed series of in-person and virtual workshops on mycotoxin sampling theory and protocols. These will be conducted with new partners at the USDA-ARS Peanut Quality Lab located at North Carolina State University.

A partnership with the non-profit engineering group, Full Belly Project, in Wilmington, North Carolina, has been initiated to evaluate their well-known Universal Nut Sheller for social acceptance, economic impact and aflatoxin reduction.

Appendices

Appendix A. Program Partners

A1. United States of America

Institution	Department	City	State
Auburn University	Department of Agronomy & Soils	Auburn	AL
California Polytechnic State University	Food Science and Nutrition	San Luis Obispo	CA
University of Connecticut	Agricultural and Resource Economics	Storrs	CT
International Food Policy Research Institute (IFPRI)		Washington	DC
University of Florida	Agronomy Department	Gainesville	FL
Creole Incorporated		Lake Worth	FL
University of Florida	North Florida Research and Education Center	Marianna	FL
Frank's Designs for Peanuts, LLC		Mexico Beach	FL
University of Georgia	Center for Applied Genetic Technologies	Athens	GA
University of Georgia	Department of Plant Pathology	Athens	GA
University of Georgia	Center for Applied Genetic Technologies	Athens	GA
University of Georgia	Department of Agricultural and Applied Economics	Athens	GA
University of Georgia	Department of Environmental Health Science	Athens	GA
United States Department of Agriculture-Agriculture Research Service (USDA-ARS)	National Peanut Research Laboratory	Dawson	GA
United States Department of Agriculture-Agriculture Research Service (USDA-ARS)	Plant Genetic Resources Conservation Unit	Griffin	GA
University of Georgia	Department of Food Science and Technology	Griffin	GA
United States Department of Agriculture-Agriculture Research Service (USDA-ARS)	Coastal Plain Experiment Station	Tifton	GA
University of Georgia	Plant Pathology	Tifton	GA
University of Georgia	Department of Plant Pathology	Tifton	GA
University of Georgia	National Environmentally Sound Production Agriculture Laboratory (NESPAL)	Tifton	GA
University of Georgia	Department of Entomology	Tifton	GA

Institution	Department	City	State
United States Department of Agriculture-Agriculture Research Service (USDA-ARS)	Food and Feed Safety Research	New Orleans	LA
Tufts University	School of Nutrition Science and Policy	Boston	MA
Meds & Food for Kids		St Louis	MO
Washington University School of Medicine	College of Medicine	St. Louis	MO
Mississippi State University	Geosystems Research Institute	Stennis Space Center	MS
United States Department of Agriculture - Agriculture Research Service (USDA-ARS)	Genomics & Bioinformatics Research Unit	Stonesville	MS
North Carolina State University	Center for Turfgrass Envionmental Research and Education	Raleigh	NC
North Carolina State University	Department of Crop Science	Raleigh	NC
New Mexico Sate University	Agricultural Science Center	Clovis	NM
Cornell University	Animal Science	Ithaca	NY
Texas A&M University	Lubbock Research & Extension Center	Lubbock	TX
Texas A&M University	AgriLife Research	Stephenville	TX
Virginia Polytechnic Institute and State University	Biological Systems Engineering	Blacksburg	VA
Virginia Polytechnic Institute and State University	Tidewater Agricultural Research & Extension Center	Suffolk	VA

A3. Foreign

Institution	Department	City
Burkina Faso		
University of Ouagadougou	Departement de Phytopathologie	Quagadougou
Ghana		
Counsel for Scientific and Industrial Research (CSIR)	Crops Research Institute (CRI)	Kumasi
Kwame Nkrumah University of Science and Technology (KNUST)	Department of Crop and Soil Sciences	Kumasi
Kwame Nkrumah University of Science and Technology (KNUST)	Food Science and Biotechnology	Kumasi
University of Ghana	Institute of Statistical, Social, and Economic Research	Legon
University of Ghana	Department of Nutrition and Food Science	Legon
Counsel for Scientific and Industrial Research (CSIR)	University for Development Studies	Tamale
Counsel for Scientific and Industrial Research (CSIR)	Savanna Agricultural Research Institute (SARI)	Wa

Institution	Department	City
Haiti		
TechnoServe		Petionville
Meds & Food for Kids		Quartier Morin
Partners in Health/Zanmi Agrikol		Corporant
Accesso Peanut Corporation		Petionville
India		
Tamil Nadu Agricultural University	Department of Plant Biotechnology	Chennai
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Grain Legumes Research Program	Hyderabad
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Center of Excellence in Genomics	Hyderabad
Kenya		
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	East and Southern Africa Regional Program	Nairobi
Kenyatta University	Plant Transformation Lab	Nairobi
Malawi		
University of Malawi	College of Medicine	Blantyre
Afri-Nut		Lilongwe
Lilongwe University of Agriculture and Natural Resources	Department of Home Economics & Human Nutrition	Lilongwe
Chitedze Agriculture Research Service		Lilongwe
Exagris Africa Ltd.		Lilongwe
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Chitedze Agricultural Research Station	Lilongwe
National Small Holder Farmers Association of Malawi (NASFAM)		Lilongwe
Mali		
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	West and Central Africa Regional Program	Bamako
Mozambique		
Edwardo Mondlane University		Maputo
Instituto de investigação Agrária de Moçambique (IIAM)		Maputo
IKURU Farmer's Cooperative		Nampula
Lurio University		Nampula
Mozambique Agricultural Research Institute	Northeast Zonal Center	Nampula
Nigeria		
International Institute of Tropical Agriculture (IITA)		Ibadan
Senegal		
Institut Senegalais de Researches Agricoles (ISRA)	Centre National de Recherches Agronomiques (CNRA)	Bambey

Institution	Department	City
Institut Senegalais de Researches Agricoles (ISRA)	Centre d'etude regional pour l'amelioration de l'adaptation a la secheresse (CERAAS)	Thies
Uganda		
National Agricultural Research Organization (NARO)	National Crops Resources Research Institute (NaCRRI)	Kampala
National Agricultural Research Organization (NARO)	Savannah Agricultural Research Institute (SARI)	Nyankpala
National Agricultural Research Organization (NARO)	National Semi Arid Resources Research Institute (NaSARRI)	Soroti
Zambia		
Eastern Province Farmer's Cooperative Ltd.	Katopola Farm Institute	Chipata
Zambia Agriculture Research Institute (ZARI)	Mt. Makulu Central Research Station	Lusaka

Appendix B. List of Awards to Partners

B1. US Partners (by State)

Institution		Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2014 Budget	Total Budget
Connecticut					**$8,673**	**$112,100**
University of Connecticut	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$7,673	$19,000
	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$1,000	$93,100
District of Columbia					**$193,312**	**$231,375**
International Food Policy Research Institute	C3.	Producer and Consumer Interventions to Decrease Peanut Mycotoxin Risk in Ghana *(sub-award from UGA)*	2/7/14	12/31/16	$193,312	$231,375
Florida					**$143,047**	**$596,681**
University of Florida (UFL)	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$78,973	$310,778
	C1.	Production to Consumption – Technologies to Improve Peanut Production, Processing and Utilization in Haiti	12/1/13	7/30/17	$42,735	$127,238
	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$21,339	$158,665
Georgia					**$809,106**	**$2,876,498**
University of Georgia (UGA)	A1.	Translational Genomics to Reduce Pre-harvest Aflatoxin Contamination of Peanut	11/1/13	7/30/17	$137,163	$527,652
	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality	11/26/13	7/30/17	$117,455	$263,501
	B2.	Development and Validation of Methods for Detection of Mycotoxins Exposure in Dried Spotted Blood Samples	9/26/13	8/31/16	$278,488	$750,000
	C1.	Production to Consumption – Technologies to Improve Peanut Production, Processing and Utilization in Haiti *(sub-award from UFL)*	12/1/13	7/30/17	$74,966	$297,261

Institution		Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2014 Budget	Total Budget
	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$41,977	$193,100
	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$15,019	$88,500
	C3.	Producer and Consumer Interventions to Decrease Peanut Mycotoxin Risk in Ghana	2/7/14	12/31/16	$31,970	$68,625
	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$47,258	$297,548
USDA-ARS National Peanut Research Laboratory (NPRL)	A2.	Silencing of Aflatoxin Synthesis through RNA Interference (RNAi) in Peanut Plants	2/7/14	7/30/17	$54,810	$350,311
USDA-ARS Plant Genetic Resources Conservation Unit	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$10,000	$40,000
Mississippi					**$198,643**	**$377,431**
Mississippi State University (MSU)	B1.	AflaGoggles for Screening Aflatoxin Contamination in Maize	10/1/14	9/30/15	$177,143	$333,971
USDA-ARS Southern Regional Research Center	B1.	AflaGoggles for Screening Aflatoxin Contamination in Maize *(sub-award from MSU)*	10/1/14	9/30/15	$21,500	$43,460
Missouri					**$64,049**	**$181,500**
Washington University (WU)	B3.	Randomized Controlled Trial of the Impact of Treating Moderately Malnourished Women in Pregnancy	11/1/13	10/31/16	$64,049	$181,500
New Mexico					**$57,710**	**$215,839**
New Mexico State University	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$57,710	$215,839
New York					**$97,133**	**$271,251**
Cornell University	C1.	Production to Consumption – Technologies to Improve Peanut Production, Processing and Utilization in Haiti *(sub-award from UFL)*	12/1/13	7/30/17	$97,133	$271,251
North Carolina					**$116,513**	**$471,011**

Institution		Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2014 Budget	Total Budget
North Carolina State University (NCSU)	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana	5/1/14	7/31/17	$64,578	$180,585
	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia	7/1/14	7/30/17	$51,935	$290,426
Texas					**$65,095**	**$241,505**
Texas A&M University	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$65,095	$241,505
Virginia					**$74,346**	**$318,855**
Virginia Tech	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$3,095	$10,631
	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$22,548	$99,593
	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$48,703	$208,631

B2. Non-US Partners (by Country)

Institution		Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2014 Budget	Total Budget
Burkina Faso					**$10,115**	**$51,717**
University of Ouagadougou	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$10,115	$51,717
Ghana					**$173,030**	**$694,065**
Crop Research Institute	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$38,900	$160,500

Institution		Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2014 Budget	Total Budget
Kwame Nkrumah University of Science and Technology	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$49,882	$205,650
Savannah Agriculture Research Institute	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$12,498	$57,608
	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$65,150	$240,750
University of Ghana	C2.	Using Applied Research and Technology Transfer to Minimize Aflatoxin Contamination and Increase Production, Quality and Marketing of Peanut in Ghana *(sub-award from NCSU)*	5/1/14	7/31/17	$6,600	$29,557
Haiti					**$122,000**	**$304,250**
Med & Food for Kids	C1.	Production to Consumption – Technologies to Improve Peanut Production, Processing and Utilization in Haiti *(sub-award from UFL)*	12/1/13	7/30/17	$122,000	$304,250
India					**$96,321**	**$388,238**
International Crops Research Institute for the Semi-Arid Tropics	A1.	Translational Genomics to Reduce Pre-harvest Aflatoxin Contamination of Peanut *(sub-award from UGA)*	11/1/13	7/30/17	$91,416	$372,350
Tamil Nadu Agriculture University	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$4,905	$15,888
Malawi					**$244,760**	**$1,007,583**
Lilongwe University of Agriculture and Natural Resources	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$18,590	$234,785
Chitedze Agriculture Research Service	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$0	$15,000
International Crops Research Institute for the Semi-Arid Tropics	A2.	Silencing of Aflatoxin Synthesis through RNA Interference (RNAi) in Peanut Plants *(sub-award from NPRL)*	2/7/14	7/30/17	$44,900	$126,401

Institution		Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2014 Budget	Total Budget
	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$114,910	$355,864
	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$26,860	$157,033
University of Malawi	B3.	Randomized Controlled Trial of the Impact of Treating Moderately Malnourished Women in Pregnancy *(sub-award from WU)*	11/1/13	10/31/16	$39,500	$118,500
Mozambique					**$30,000**	**$199,072**
Mozambique Agricultural Research Institute (IIAM)	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$30,000	$135,000
	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$0	$64,072
Nigeria					**$5,750**	**$22,425**
International Institute of Tropical Agriculture	B1.	AflaGoggles for Screening Aflatoxin Contamination in Maize *(sub-award from MSU)*	10/1/14	9/30/15	$5,750	$22,425
Senegal					**$51,500**	**$100,000**
Senegal Agriculture Research Institute	A1.	Translational Genomics to Reduce Pre-harvest Aflatoxin Contamination of Peanut *(sub-award from UGA)*	11/1/13	7/30/17	$51,500	$100,000
Uganda					**$80,959**	**$305,177**
National Agriculture Research Organization	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$7,000	$34,000
National Crops Resources Research Institute	A2.	Silencing of Aflatoxin Synthesis through RNA Interference (RNAi) in Peanut Plants *(sub-award from NPRL)*	2/7/14	7/30/17	$8,510	$23,288
National Semi Arid Resources Research Institute	A3.	An Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality *(sub-award from UGA)*	11/26/13	7/30/17	$65,449	$247,889
Zambia					**$22,869**	**$232,505**
University of Zambia	C4.	Aflatoxin Management Interventions, Education and Analysis at Various Steps Along the Peanut Value Chain in Malawi, Mozambique and Zambia *(sub-award from NCSU)*	7/1/14	7/30/17	$22,869	$232,505

Appendix C. Success Stories

Photo courtesy of Mark Manary.

C1. Release of High-Yielding and Drought Tolerant Peanut Varieties in Uganda

Co-Principal Investigator David Kalule Okello, working with Principal Investigator Mike Deom on the Peanut & Mycotoxin Innovation Lab (PMIL) project "Integrated Global Breeding and Genomics Approach to Intensifying Peanut Production and Quality," has successfully developed, released and distributed 14 improved varieties of high-yielding drought resistant peanuts in Uganda: Serenut 1R, 2T, 3R, 4T, 5R, 6T, 7T, 8R, 9T, 10R, 11T, 12R, 13T, and 14 R.

Improving yields and quality through inputs such as fertilizer, herbicides and insecticides is fiscally impractical for smallholder groundnut farmers. Therefore, research efforts have endeavored to breed varieties that are high-yielding, resistant to major pests and diseases, tolerant to drought, high in oil content and have a short to medium maturity to avoid the aflatoxin-inducing late season drought stress.

These 14 new red and white varieties of groundnut are highly resistant to drought, groundnut rosette disease and early leaf spot. They are also being widely adopted in Uganda, and other countries in Eastern and Southern Africa.

PMIL in-country project co-Principal Investigator David Okello, who is head of the National Groundnut Improvement Program at the Uganda National Agricultural Research Organization (NARO), has helped local farmers to "cash in" on the improved varieties.

Okello has been working with a local farmers' cooperative (Aye Medo Ngeca), supplying them with several of the improved seed varieties. They, in turn, have been obtaining higher yields and selling the improved groundnut seed to other farmers in the local community. During a visit this year by PMIL Director, Dave Hoisington, Mr. Sunday Opolot, who is one of the farmers in the cooperative, told him that the improved varieties make good economic sense and that they are only limited by the amount of seed they can plant – something that PMIL is working with the cooperative on.

During Hoisington's visit, the two David's also met with the President of Bulogo, a women's group in Uganda, and made plans for them to start planting the improved varieties and ultimately distributing them to their farmers.

The success and adoption of the improved groundnut varieties has been the focus of several media stories, including a recent blog article.

Okello continues to develop and evaluate new varieties and is conducting national performance trials in Uganda. He is also screening for new sources of resistance to drought, early leaf spot disease and groundnut rosette disease in Zambia.

For more details, see the following link:

> http://paulndiho.com/2014/02/20/ugandan-groundnut-farmers-cashing-in-on-improved-new-varieties/

Dave Hoisington and David Okello meet with farmers producing seed of new Serenut varieties in Uganda. Photo courtesy of David Okello.

Meeting with Aye Medo Ngeca to peanut seed production in Uganda. Photo courtesy of David Okello.

C2. Boosting Peanut Supply in Haiti via Acceso Peanut Enterprise Corporation Partnership

The Peanut & Mycotoxin Innovation Lab (PMIL) research in the focus country of Haiti saw several major accomplishments in the last year.

Peanut research and supply channels in Haiti were boosted through an initiative developed by the Clinton Giustra Enterprise Partnership – the new Acceso Peanut Enterprise Corporation. The Haitian for-profit supply chain enterprise is designed to improve the livelihoods of more than 12,000 smallholder peanut farmers. The PMIL Director, Assistant Director and Communications Specialist were present during the launch of the Acceso depot in the Central Plateau by President Bill Clinton and Frank Giustra in July 2014.

Acceso's business plan is to organize a network of depots that will serve as a type of trading post for farming communities. Through the depots, Acceso will sell seed, inputs and services, as well as provide technical training and a market once the crops are harvested. Acceso's network also provides quality control for aflatoxin contamination and market linkages to regional buyers that require high quality groundnuts, including Meds & Food for Kids and Partners in Health, which are both manufacturers of peanut-based therapeutic products for treatment of severely malnourished children.

The new Clinton Giustra Enterprise Partnership is using technical advice, training in peanut production and technologies, such as improved varieties and mechanization, provided by PMIL scientists, particularly Tim Brenneman and Bob Kemerait at The University of Georgia. They are both collaborators on PMIL's, "Haiti Peanut Value Chain Intervention," project and have worked in Haiti since 2007 with in-country collaborator Meds & Food for Kids.

The Technical Centre for Agriculture and Rural Cooperation, known as CTA, has recently recognized the innovative techniques of managing aflatoxin in smallholder groundnut production developed through this long-term collaboration as one of their "Top 20 Innovations for Smallholder Farmers." Meds & Food for Kid's work was selected from a field of over 250 entries and was voted on by farmer organizations in Africa, the Pacific and the Caribbean. PMIL's Assistant Director Jamie Rhoads, who previously worked for Meds & Food for Kids in Haiti, represented this project at a CTA "write-shop" that developed extension materials that will share this suite of technologies across Africa, the Pacific and the Caribbean.

These ongoing efforts have raised awareness of aflatoxin as a public health risk at the national level in Haiti, instigating a planned conference on aflatoxin among Ministries to accompany PMIL's annual meeting to be held in Haiti.

For more details, see the following links:

https://www.clintonfoundation.org/our-work/clinton-giustra-enterprise-partnership/programs/acceso-peanut-enterprise-corporation

http://pmil.caes.uga.edu/documents/UF155/PeanutProductionGuideGuyana2007.pdf

http://georgiafaces.caes.uga.edu/index.cfm?public=viewStory&pk_id=5273

Former President Bill Clinton attends the opening of the new Acceso Peanut Corporation Depot in Haiti, an initiative supported by the Clinton Guistra Enterprise Partnership. Photo courtesy of Christy Fricks.

Women shell peanuts by-hand in Haiti. Photo courtesy of Bob Kemerait.

C3. Peanut Butter can Serve as a Vehicle to Deliver Probiotics

Diarrheal disease is the second leading cause of death and number one leading cause of malnutrition in children under five years old, according to the World Health Organization. Probiotics – organisms such as bacteria or yeast that are believed to improve health – have been shown to significantly reduce the severity and duration of acute diarrhea and improve the health of the human gut.

Malnourished children have poor immunity and impaired gut integrity, making them prone to infections. Probiotics are known to address the above problems and consequently aid in proper absorption and utilization of nutrients. Adequate utilization of nutrients will help in recovery from malnutrition and thus, it is important to address intestinal health together with nourishment.

Recent results from the successful completion of a Peanut & Mycotoxin Innovation Lab-supported PhD student thesis research has indicated that peanut butter is an excellent vehicle to carry probiotics to malnourished children in developing countries who suffer from diarrhea.

Ms. Yaa Asantewaa Kafui Klu, a female graduate student from Ghana, completed her PhD in Food Science from the University of Georgia in the Fall of 2014. Klu conducted her dissertation research in a new and vital area – the role that peanut-based foods can play in delivering probiotics to malnourished children.

Peanut butter is a low-moisture, shelf stable, energy and nutrient dense product and is well known as a primary ingredient in 'Ready to Use Therapeutic Foods' (RUTFs), which are used to treat severe malnutrition in children. However, these same characteristics that make peanut butter ideal for RUTF because it is difficult to grow “bad” bacteria, also supposedly would make it a less than ideal medium for the “good” bacteria in probiotics. Klu chose to investigate whether this was true by evaluating various aspects of using peanut butter as a probiotic delivery mechanism.

In May 2014, Yaa Klu published, “Survival of four commercial probiotic mixtures in full fat and reduced fat peanut butter,” in the journal *Food Microbiology*. The study revealed that one strain of probiotic had a greater survivability rate than others and that fat had no effect on the probiotic viability.

These results contradicted the general wisdom and indicate that peanut butter can be an effective vehicle to deliver probiotics as part of either a preventative or therapeutic treatment. Such a success could have significant outcomes in providing an effective delivery mechanism to combat diarrhea.

Klu has already won awards for her graduate studies and presented papers across the U.S.A. on her research. Klu ’s studies were originally supported by funds from the Peanut CRSP, and have been continued by PMIL.

Klu plans to continue her research upon returning to Ghana, with a focus on weaning foods in particular.

To access Klu’s published research:

http://www.sciencedirect.com/science/article/pii/S0740002014000938

For more information about Klu: http://pmil.caes.uga.edu/contact/KluY.html

Yaa Klu conducting her thesis research on probiotics in the lab at University of Georgia, Griffin. Photo courtesy of Yaa Klu.

Yaa Klu at the University of Georgia Graduation, 2014.
Photo courtesy of Yaa Klu.

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