FEED THE FUTURE

The U.S. Government's Global Hunger & Food Security Initiative

Peanut Innovation Lab

Annual Report
Fiscal Year 2019

Feed the Future
Innovation Lab for Peanut

(Peanut Innovation Lab)

Annual Report – Fiscal Year 2019

(1 October 2018 – 30 September 2019)

Peanut Innovation Lab Management Entity
University of Georgia, Athens, Georgia
30 November 2019

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Acronyms

AAGB	Advances in Arachis Genomics and Biotechnology
AB-QTL	advanced backcross-quantitative trait loci
ANCAR	Agence Nationale de Conseil Agricole et Rural, Senegal
AOR	Agreement Officer's Representative
APPSA	African Productivity Program for Southern Africa (World Bank)
ARS	Agricultural Research Service
BMS	Breeding Management System
CERAAS	Centre d'Etude Régional pour l'Amélioration de l'Adaptation á la Sécheresse, Senegal
CERRA	Centre Régional de la Recherche Agronomique, Niger
CIMMYT	Centro Internacional de Mejoramiento de Maíz y Trigo, Mexico
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement, France
CNRA	Centre National de Recherches Agronomiques, Senegal
Co-PI	co-principal investigator
CRI	Crops Research Institute, Ghana
CRRA	Centres Régionaux de Recherche Agronomique, Mali
CRSP	collaborative research support program
CSIR	Council for Scientific and Industrial Research, Ghana
CSSL	Chromosomal Segment Substitution Line
DARS	Department of Agricultural Research Services, Malawi
EAP	External Advisory Panel
EBCA	Enhancing Breeding Capacity in Africa
ESA	East and Southern Africa
FENAB	Fédération Nationale pour l'Agriculture Biologique, Senegal
FY19	Fiscal Year 2019
GGWG	Ghana Groundnut Working Group
GRD	groundnut rosette disease
GREAT	Gender-responsive Researchers Equipped for Agricultural Transformation
GRV	groundnut rosette virus
GWAS	genome-wide associations studies
GxE	genotype by environment
HTP	high-throughput phenotyping
IBP	Integrated Breeding Platform
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics, India
IER	Institut d'Economie Rurale, Mali
IFAD	International Fund for Agricultural Development
IFPRI	International Food Policy Research Institute, USA
IIAM	Instituto de Investigação Agrária de Moçambique, Mozambique
INRA	Institut National de la Recherche Agronomique, Mali
INRAN	Institut National de la Recherche Agronomique du Niger
IRB	Institutional Review Board
ISRA	Institut Sénégalais de Researches Agricoles, Senegal
ITRA	Institut Togolais de Recherche Agronomique, Togo
IVSC	*in-vitro* seed colonization
KNUST	Kwame Nkrumah University of Science and Technology, Ghana
LLS	late leaf spot
LUANAR	Lilongwe University of Agricultural and Natural Resources, Malawi
ME	Management Entity
NaCRRI	National Crops Resources Research Institute, Uganda
NARO	National Agricultural Research Organization, Uganda
NARS	National Agricultural Research System
NaSARRI	National Semi-Arid Resources Research Institute, Uganda
NCSU	North Carolina State University, NC
NIFA	National Institute for Food and Agriculture, USA
NPRL	National Peanut Research Lab, GA
OSS	optimized shrub system
PI	principal investigator
PMIL	Peanut and Mycotoxin Innovation Lab
QDS	quality declared seed
QTL	quantitative trait loci
SARI	Savannah Agricultural Research Institute, Ghana
SNP	single-nucleotide polymorphism
SPAD	Soil-Plant Analysis Development
UGA	University of Georgia, GA
USAID	United States Agency for International Development
USDA	United States Department of Agriculture
ZARI	Zambian Agricultural Research Institute, Zambia

Management Entity Information

The Peanut Innovation Lab Management Entity is hosted by the University of Georgia's College of Agricultural and Environmental Sciences in Athens, GA. Current staff includes Dave Hoisington (Director), Jamie Rhoads (Assistant Director), Allen Stripling (Business Manager), Allison Floyd (Communications Coordinator), Bonnie Klostermann (Administrative Specialist) and Jessica Marter-Kenyon (Gender and Youth Post-doctoral Associate).

External Advisory Panel

The External Advisory Panel (EAP) continues to provide feedback on the research progress by attending project launch workshops and project events in-country, as well as reviewing semi-annual and annual reports. Samara Sterling, research director for The Peanut Institute, has agreed to serve on the EAP and provides expertise in the area of nutrition.

Program Countries

The Peanut Innovation Lab focus countries are Ghana, Malawi, Senegal and Uganda. Certain projects have research activities in India, Kenya, Mali and Niger.

Program Partners

United States of America

Institution	Department	City	State
International Food Policy Research Institute (IFPRI)		Washington	DC
Iowa State University		Ames	IA
North Carolina State University (NCSU)	Department of Crop and Soil Sciences	Raleigh	NC
The Ohio State University	International Programs in Agriculture	Columbus	OH
	School of Environment and Natural Resources	Columbus	OH
Pennsylvania State University	College of Agricultural Sciences	University Park	PA
Stanford University	Center of Food Security and the Environment	Stanford	CA
Texas A&M University		Lubbock	TX
Texas Tech University	Department of Plant & Soil Science	Lubbock	TX
United States Department of Agriculture-Agriculture Research Service (USDA-ARS)	Market Quality & Handling Research	Raleigh	NC

Institution	Department	City	State
	National Peanut Research Laboratory (NPRL)	Dawson	GA
	Plant Genetic Resources Conservation Unit	Griffin	GA
University of California, Santa Barbara, (UCSB)	Department of Geography	Santa Barbara	CA
University of Florida	Institute of Food and Agricultural Sciences	Gainesville	FL
University of Georgia (UGA)	Department of Agricultural and Applied Economics	Athens	GA
	Department of Crop and Soil Sciences	Athens	GA
	Department of Entomology	Athens	GA
	Department of Environmental Health Science	Athens	GA
	Department of Horticulture	Tifton	GA
	Department of Plant Pathology	Athens	GA
University of Tennessee	Institute of Agriculture	Knoxville	TN
Virginia Polytechnic Institute and State University	College of Agriculture & Life Sciences	Blacksburg	VA
	Department of Plant Pathology Physiology & Weed Sciences	Suffolk	VA
Washington University, St. Louis	School of Medicine	St. Louis	MO

Foreign

Institution	Department	City
Ghana		
Council for Scientific and Industrial Research (CSIR)	Crop Research Institute (CRI)	Kumasi
	Savannah Agricultural Research Institute (SARI)	Nyankpala
Kwame Nkrumah University of Science and Technology (KNUST)		Kumasi
Project Peanut Butter		Kumasi
University for Development Studies (UDS)		Tamale
University of Ghana	School of Biological Science	Accra
India		
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)		Patancheru
Kenya		
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)		Nairobi
Malawi		
Department of Agricultural Research Services (DARS)	Chitedze Research Station	Lilongwe
Horizon Farms		Bunda
Lilongwe University of Agricultural and Natural Resources (LUANAR)	Crop and Soil Sciences Department	Lilongwe

Institution	Department	City
Mexico		
Centro Internacional de Mejoramiento de Maíz y Trigo (CIMMYT)	Integrated Breeding Platform (IBP)	Mexico City
Mali		
Institut d'Economie Rurale (IER)	Centres Régionaux de Recherche Agronomique (CRRA)	Bamako
Mozambique		
Instituto de Investigação Agrária de Moçambique (IIAM)	Northeast Zonal Center	Nampula
Niger		
Centre Regional de la Recherche Agronomique du Niger (INRA)	Centre Régional de la Recherche Agronomique (CERRA)	Niamey
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Sahelian Centre	Niamey
Senegal		
Centre de Recherche Pour le Developpement Economique et Social Sanar (CRDESS)		Saint-Louis
Ecole Nationale Superieure d'Agriculture de Thies		Thies
Institut Sénégalais de Reserches Agricoles (ISRA)	Centre d'Etude Régional pour l'Amélioration de l'Adaptation à la Sécheresse (CERAAS)	Thies
	Centre National de Recherches Agronomiques (CNRA)	Bambey
University of Thies		Thies
Uganda		
Makerere University	College of Agricultural and Environmental Sciences	Kampala
	Department of Disease Control and Environmental Health	Kampala
	School of Women and Gender Studies, Makerere University	Kampala
National Agricultural Research Organization (NARO)	National Crops Resources and Research Institute (NaCRRI)	Namulonge
	National Semi Arid Resources Research Institute (NaSARRI)	Soroti
Zambia		
Zambia Agriculture Research Institute (ZARI)	Msekera Research Station	Chipata

Executive Summary

By the end of Fiscal Year 2019, the Peanut Innovation Lab had approved its full portfolio of 26 projects. It had also conducted launching workshops in Uganda and Ghana that brought together US and in-country partners and students to discuss the planned research and identify areas for collaboration between the projects and other USAID support activities in the country. These workshops gave excellent opportunities for the project teams to finetune work plans, and for students who would be supported by the projects to meet with their mentors and define their research. Similar workshops are planned for Senegal and Malawi before the end of 2019.

The commissioned projects ended, after producing the planned outputs that are now part of larger competitive projects. A particular highlight was the completion of the SNP genotyping of 1050 lines contributed by 10 national peanut breeding programs in nine African countries. All breeders and scientists involved in the project met in Senegal in June to analyze the results and identify a set of 300 lines that represent the diversity across Africa. The breeders also received training in analysis and use of SNP data along with the all of the genotyping data and software required for analysis. Seed of the 300 lines is being increased in Senegal and Uganda for distribution to all breeders for field trials starting next year. The analysis has already helped the breeders to understand the diversity in their materials and see what other materials would help increase that diversity, while identifying a number of duplications and similarities that need to be checked for accuracy. This collection will also form the basis for the High Throughput Phenotyping project in Senegal, Uganda and Ghana. A second project is about one-third complete to SNP genotype over 2500 lines that originated from Africa and are in the USDA peanut genebank.

Ibrahima Diedhiou of the University of Thies in Senegal talks to Innovation Lab Director Dave Hoisington. Diedhiou studies how wild shrubs in the Sahel region may improve crop yields and remediate degraded soils. Now, he's testing how the shrubs work in Senegalese farmers' peanut fields. (Photo by Allison Floyd)

The African breeders continue to network, solve problems, and follow research progress. All programs are using the Breeding Management System (BMS) to manage their breeding programs. This will be important in managing and sharing the data generated through field evaluations of the above 300 core set and other new materials supplied by US researchers under the Peanut Innovation Lab projects. So far, over 500 new lines containing resistance to diseases and tolerance to drought from wild species have been sent from the US, along with over

500 lines from several segregating populations to use in identifying the genetics of these traits. The materials are being increased in Senegal, Ghana and Uganda for evaluation next year.

Ghanaian partners held the first Ghana Groundnut Working Group (GGWG) meeting in Tamale. The meeting brought together a wide range of stakeholders along the peanut value chain to discuss the importance of peanuts and challenges to production, use and consumption. The groups established a local organizing committee that is planning for the second meeting in 2020. The concept for such a group is based on the American Peanut Research and Education Society that started some 50 years ago in a similar fashion and today attracts global interest to meet and discuss the latest findings in peanut.

Many other projects were also able to initiate research activities, including surveying for the alternative host(s) of groundnut rosette virus, a devastating peanut viral disease in Africa; mapping of resistance genes to the virus; identification of genes in peanut that are associated with resistance to *Aspergillus flavus*, which produces aflatoxin; and formulation of new peanut-based school foods developed for testing in Ghana next year.

Other projects researching production packages, effects of peanut on the gut microbiome, and gender and youth constraints in the peanut value chain are building their teams and initiating activities. In 2020, we will be conducting our first gender training workshops for all researchers and students and our first Peanut Innovation Lab Research Meeting.

Program Activities and Highlights

Networking with industry

The management entity engaged private-sector partners in Bangladesh and Malawi, leading delegations from both countries to visit the U.S.

Assistant Director Jamie Rhoads demonstrates a small-scale sheller in a training in Malawi.

The director and assistant director visited Bangladesh on 10-15 February at the invitation of the USAID mission and Partex Agro to survey peanut farms and processing plants. The team included the director of UGA's Office of Global Programs, Amrit Bart, and Frank Nolin, a retired manufacturer of peanut equipment in the USA. The team spent five days visiting farms in the north and central production areas, local peanut sellers in Dhaka, the Bangladesh Agricultural Research Institute, and a Partex food manufacturing plant that produces peanut snacks. A meeting with USAID mission staff was held at the beginning and end of the visit. The team recommended to the mission and Partex ways to

improve the peanut value chain and continues to explore activities with the Rice and Diversified Crops Activity funded by the local mission and administered by ACDI-VOCA.

The director, assistant director, Nolin and David Jordan (NCSU peanut extension specialist) provided training to Limbe Leaf and Alliance One extension staff in Malawi from 11-15 March. The training focused on appropriate methods to determine peanut maturity and other issues related to the end of the production cycle. The team met with the Department of Agricultural Research Services (DARS) and demonstrated a hand-operated peanut sheller, aspirator and grading table designed and built by Nolin at the request of the Peanut Innovation Lab. The equipment was demonstrated to Limbe Leaf and Alliance One during the training sessions and left at DARS to assist in the peanut breeding program.

Following those visits, delegations from Malawi and Bangladesh came for the three-day Georgia Peanut Tour in July, and the Peanut Innovation Lab arranged for additional tours of food-testing company JLA labs, a Birdsong Peanuts buying point, and the Georgia Seed Development facility in Plains, GA, to give the groups more information about production in the US.

Presenting about the lab

The director and others presented about the lab at conferences and meetings, including:

- Arachis Genomics and Biotechnology (AAGB) Conference in Saly, Senegal from 12-14 November 2018.
- ICRISAT in Hyderabad, India on 7-8 February. The visit provided an opportunity to discuss collaborative activities in peanut breeding and seed-coat technology.
- USAID mission staff in Kampala, Uganda on 6 March. The discussion, which included the Uganda national program peanut breeder, defined specific areas of interest to the mission and mission-supported activities that should be linked with Innovation Lab projects.
- USAID mission staff in Malawi, 15 March, to discuss work with the mission supported Ag Diversification Activity, a Feed the Future-funded project to diversify products in that country.
- Innovation Lab directors in meetings in Addis Ababa, Ethiopia and Washington, DC
- The American Peanut Research and Education Society annual research meeting. The lab organized a symposium on international research for the 500-plus person conference and conducted a specific session on innovation lab technologies.

Co-creation of research projects

The management entity met with scientists to design projects together in order to maximize research outputs.

Following the AAGB meeting in November 2018, scientists working in variety development met to discuss their projects, allowing the team to identify core varieties to use across several projects and develop start-up plans for projects in each country.

In Kampala, Uganda in early March, the director and gender-and-youth post-doc met with scientists in the gut microbiome nutrition and photovoice youth empowerment projects to define the critical issues that will need to be resolved at the start of each project. In meetings with the

Gender-responsive Researchers Equipped for Agricultural Transformation (GREAT) director and team at Makerere University, team developed plans to provide all program scientists and students with gender training.

Whole-team launch meetings with gender baseline

The Peanut Innovation Lab held successful launch meetings for projects in Uganda and Ghana (with a third in Senegal just after the reporting deadline), bringing together PIs from across disciplines to present about their projects, find synergies between projects, and begin working with in-country graduate students. These meetings also provided an opportunity to survey PIs, co-PIs, collaborators and students to get a baseline for their knowledge and feelings about gender-responsive research.

By planning these projects in conjunction with other events, the Innovation Lab was able to support other initiatives, including the inaugural meeting of the Ghana Groundnut Working Group (GGWG), a gathering of researchers and others who work along the peanut value chain in that country.

Program management

The Piestar DPx project management software was used to request and receive progress reports for this report. The Management Entity has worked with Piestar to develop the modules for the project PIs and other scientists to report progress, request approvals to travel, purchase supplies, train students and register for events. Modules also have been implemented to collect information on project progress, degree training, short-term training events, data management, EMMP activities and technology pipelines, as well as for PIs to submit annual work plans and budgets.

Key Accomplishments

Over 1,100 African peanut lines have been genotyped using the recently available SNP chip that detects over 35,000 loci in the peanut genome. The data was used to identify a core set of 300 lines that represent the diversity across Africa. The assessment data is being used by the breeding programs across Africa to better understand their materials, remove duplications and use more diverse materials. The core set will be sent to several breeders for evaluation under field conditions, creating data will be used to determine trait-marker associations and to develop new varieties.

Over 400 new lines containing introgressions from wild peanut species and almost 500 lines from six segregating populations were transferred to African breeding programs in Senegal and Uganda. Seed of these materials is being produced for distribution to other breeding programs and to evaluate under field conditions to identify new sources of tolerance to drought and resistance to pest and diseases.

A new high-oleic peanut variety has been released by the national program in northern Ghana. Seed of the new variety is being produced to distribute to farmers. This represents the first high-

oleic variety released in Africa. High oleic varieties are of great interest given their longer shelf life and potentially improved health benefits.

An appropriately scaled peanut sheller, aspirator and grading table was designed, built and tested in partnership with a USAID Malawi mission project. The system was combined with a moisture meter and tablet-based aflatoxin testing system to create a "peanut buying point in-a-box". The system has been installed at 6 buying points of Pyxus Ltd. in Malawi in time for the 2019 harvest. The initial use showed the system has potential to determine the quality of peanuts local farmers are selling, as well as improve research efficiency.

A production risk index software tool developed by North Carolina State University has been updated to allow scientists to refine the tool for US producers and to adapt the tool to use in other countries according to conditions and needs of overseas partners. Initial versions for Malawi and Ghana have been populated with local input and testing will commence in 2020. The project funding allowed for timely development of the tool for integration in other projects across our target countries and the tool has been a provocation for updating recent findings prior to finalizing research protocols in those projects.

A country-wide initiative to integrate public and private sector interests to support the peanut value chain in Ghana was launched with support from the lab and local partners. The initial meeting of the Ghana Groundnut Working Group was held in conjunction with the country start up meeting and included producers, traders, processors, researchers and consumer groups.

Nearly 130 farmers were trained in peanut seed production in Malawi, Uganda and Zambia. Breeders in Malawi, Mozambique, Uganda and Zambia began using the Breeding Management System software in their breeding programs to produce trial designs, print seed packets and collect data electronically in the field.

Research Program Overview and Structure

The Peanut Innovation Lab contributes to the Global Food Security Strategy by increasing the production, sustainability and profitability of peanut production in targeted developing countries and the US. This will be achieved through research linkages between US and developing country scientists in four Areas of Inquiry: 1) improved peanut varieties, 2) increased value-added gains along the peanut value chain, 3) increased understanding of peanut consumption, and 4) increased understanding of gender and youth dimensions along the peanut value chain.

Area of Inquiry 1 (Improved Varieties) builds partnerships between peanut breeding programs in the US and target countries to use modern genomic and information technologies in the breeding programs. The objective is to enhance the capacity of peanut breeding programs in each country to develop new varieties using modern approaches, and to test and release varieties that increase yields and address the local, national and regional demands of the country.

Area of Inquiry 2 (Value-Added Gains) builds partnerships between the public and private sector and establishes new partnerships in seed production and local processing. Research focuses on seed production of improved varieties, best management practices to optimize quantity and quality of the crop by smallholder farmers, and effective practices for harvesting, drying, storage and shelling.

Area of Inquiry 3 (Nutrition) uses linkages with the US Peanut Institute to assess the benefits of peanut-based foods for school feeding programs, impacts of peanut consumption on human microbiota and an assessment of the nutritive value of peanut products and cooking processes in Africa.

Area of Inquiry 4 (Gender and Youth) seeks a better understanding of the roles of gender and youth in peanut value chains in each target country based on scientific studies, and examples of gender-sensitive research products having impacts.

Theory of Change and Impact Pathway

The main objective of the Peanut Innovation Lab is to support research that leads to the increased production, sustainability and profitability of peanuts in targeted developing countries. This objective will be met through joint research and capacity building between US and developing country partners. Ultimately, the results are a part of the US government goals as defined under the Global Food Security Strategy.

Significant outputs from the Peanut Innovation Lab research include:

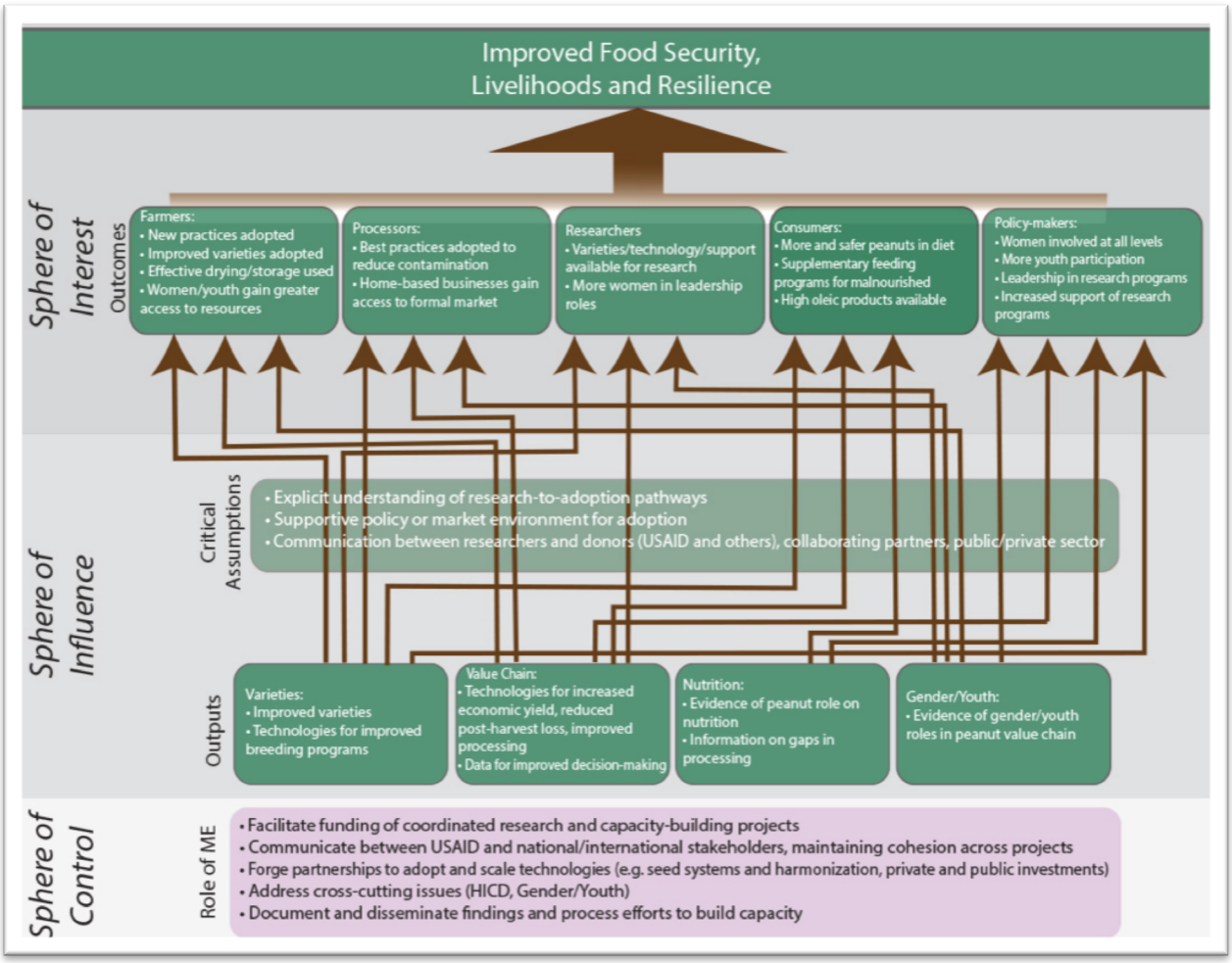
- molecular markers for drought and disease resistance,
- novel germplasm that contains genetic materials from wild relatives,
- phenotyping tools to more rapidly identify the best varieties under field conditions,
- improved varieties with enhanced productivity and nutritional traits, and
- new agronomical practices that combine inputs such as inoculants, fertilizers, and weed/pest/disease management.

As these outputs are developed in collaboration with the intended users (national program scientists), the chances for rapid adoption and use are high. A major assumption is that the intended users have the proper training and capacity to use the output. The Peanut Innovation Lab is investing in training in the use of molecular technologies, guidance in the crossing of new germplasm, application of phenotyping tools, and appropriate use of agronomic packages. The innovation lab also invests in building capacity within the partners by supplying most of the technologies (e.g., phenotyping tools) as part of the research project. Through the uptake of the new technologies, researchers will be able to more rapidly develop improved varieties that allow farmers to meet market opportunities and deal within unpredictable environmental stresses. Farmer adoption of new varieties will lead to larger and more reliable yields. The increased production will impact the household by making more food available for consumption and for sale in local markets, creating income to meet other household needs.

A major assumption is that government support for groundnut production and consumption continues and even increases. Government stability will also be important to maintain market opportunities and government funding.

Other outputs from the Peanut Innovation Lab research include appropriately scaled mechanization for shelling and grading groundnuts and new peanut-based school foods. These outputs will be delivered as part of research and development projects to potential users and consumers. Initial uptake will be by the national programs and private sector (in the case of mechanization) and public and private schools (in the case of school foods). Training in the

manufacturing and processing of these technologies will be provided to local entrepreneurs,



leading to opportunities for in-country production and marketing. Mechanization is seen as an important step in improving the production and profitability of peanut and as the uptake of appropriate technology happens, production of quality peanuts will grow. This will lead to more opportunities to reach markets (in-country, regional and global), increasing the economic returns for all value-chain actors.

Finally, research on the effects of peanut consumption on cognitive learning and gut health, and on gender and youth involvement along the peanut value chain will result in new knowledge. Our research partners will be able to use such knowledge to address key constraints in peanut value chain, improving overall production. Transfer of the knowledge to other stakeholders via workshops, policy reports, etc. allows dissemination. Key information could lead to policies favorable to peanut production, use and consumption, including gender equality and addressing youth issues.

The following diagram gives an overview of the impact pathway, moving from the spheres of control and influence under the Peanut Innovation Lab control, to the sphere of interest and ultimate desired outcomes.

Varietal Development Project Reports

Adoption of the Breeding Management System (BMS) by national programs

PI: David Okello Kalule, NARO-NaSARRI, Uganda

Research Locations

NARO-NaSARRI, Soroti, Uganda; DARS-Chitedze Research Station, Lilongwe, Malawi; ZARI, Chipata, Zambia; IIAM, Nampula, Mozambique

Description

This project, a commissioned project initiated in early 2018 for one year, aims to improve the efficiency of plant breeding programs in target countries by enabling plant breeders to access a modern analytical pipeline, breeding technologies/materials and related information in a centralized, integrated and practical manner, and to deliver improved varieties that meet local farmers' needs and market demand.

Specifically, the project will provide the necessary hardware and software for breeding programs in three countries (Malawi, Mozambique and Zambia) that are part of the peanut breeding network in Africa but have not been able to adopt the tools due to a lack of resources. The project is jointly implemented with the Integrated Breeding Platform (IBP) and involves the deployment and use of the Breeding Management System (BMS) developed by the IBP.

Theory of Change/Impact Pathway(s)

Use of digital informatics software will lead to more efficient and effective breeding programs, resulting in better varieties in less time. These varieties can then reach farmers faster, giving them higher yields that improve their household food security.

Collaborators

Justus Chintu, DARS, Malawi; Lutangu Makweti, ZARI, Zambia; Amade Muitia, IIAM, Mozambique; Graham McLaren, IBP, Mexico.

Achievements

Four national program plant breeders (Amade Muitia-IIAM, Lutangu Makweti ZARI, Justus Chintu-DARS and David Kalule Okello-NARO-NaSARRI) and graduate student (Esther Achola) were trained in the use of BMS during a three-day workshop in May 2018 by the IBP team (Jean-Marcel Ribaut, Alioune Mbow, Graham McLaren and Mable Mulanya), and Peanut Innovation Lab management (Dave Hoisington, Jamie Rhoads).

Each national program received a laptop, barcode printer, wi-fi router and internet service required for the BMS to function properly. Barcode scanners were installed, and breeders trained in their use; trial field books were designed and populated, and trial designs generated and barcoded in BMS.

The IBP Uganda-based support scientist, Mable Mulanya, met with each breeder on-site in each country during the cropping cycle to assist with capturing data. The breeders designed all of their trials and nurseries for the entire cropping season in BMS and were using electronic tablets to capture data in the field. Each breeder had at least 10 trials evaluated in multiple locations.

A final training workshop on data analysis was conducted in May 2019 to relay new BMS functionalities, how to analyze data and interpret the results.

Capacity Building

The national program partners in Malawi, Mozambique and Zambia were each supplied with a laptop, electronic tablet, barcode printer complete with cartridges and paper, and internet router/modem with annual unlimited data.

A total of 95 breeders, technicians and field staff (66 male, 29 female) received training or instruction on BMS functionalities and electronic data capture.

Lessons Learned

While the software comes in a local and a cloud-based version, the cloud-based system was found to be more suitable for many users and therefore, was more quickly adopted, even though it requires internet connectivity.

Social media can be used to build teams. The breeders have a WhatsApp group to discuss BMS and peanut breeding issues. The Uganda NaSARRI peanut team uses a WhatsApp group to resolve BMS-related issues and generally run the breeding program.

Presentations and Publications

None to date.

Assessment of breeding program needs and seed production

PI: David Okello Kalule, NARO, Uganda

Research Locations

NARO-NaSARRI, Soroti, Uganda; DARS-Chitedze Research Station, Lilongwe, Malawi; ZARI, Chipata, Zambia; IIAM, Nampula, Mozambique; CSIR-CRI, Kumasi, Ghana; CSIR-SARI, Tamale, Ghana; ISRA-CERAAS, Thies, Senegal

Description

This second commissioned one-year project targeted the production of sufficient breeder and foundation seed of improved varieties, and the assessment and prioritization of national peanut breeding program needs in the target countries for effective participation in future Peanut Innovation Lab projects.

Seed roadmaps for varieties and a template for assessing the breeding needs of each program were developed during the launch meeting in May 2018 in Kampala, Uganda, involving peanut breeders from Ghana, Malawi, Mozambique, Senegal, Uganda and Zambia, the Management Entity, and representatives from the IBP and Syngenta's Seed2B program.

Theory of Change/Impact Pathway(s)

Addressing the key constraints in breeding programs will lead to more efficient and effective programs, resulting in better varieties in less time. Improving the production of early generation seed (breeder, foundation) makes it easier to produce quality certified seed for farmers. When farmers have quicker access to higher quality varieties, they experience higher yields that improve household food security.

Collaborators

James Asibou, CSIR-CRI & Richard Oteng Frimpong, CSIR-SARI, Ghana; Justus Chintu, DARS, Malawi; Issa Faye, ISRA & Daniel Fonceka, CERAAS, Senegal; Lutangu Makweti, ZARI, Zambia; Amade Muitia, IIAM, Mozambique

Achievements

Each plant breeder conducted a needs assessment of each respective breeding program. The needs assessment allows for the competitive projects to address these in their proposed capacity-building efforts. The Peanut Innovation Lab Management Entity is also better able to target competitive and commissioned capacity-building efforts and discuss with local USAID missions and other donors their support for capacity building.

Uganda: 50 tons of Quality Declared Seeds (QDS) for planting in 2019 were produced and breeder seed (0.5t for Serenuts 11T and 14R) distributed to local seed businesses, who will monitor their 2019 QDS production alongside the National Seed Certification authority. Two tons of breeder seed was produced of the soon-to-be-released varieties, DOK 1T and 1R. This starter seed will boost post-release seed multiplication.

Mozambique: Three different field sites were used for seed production (Montepuez and Nampula on station, and Balama with a women farmers group). In Montepuez, 1 hectare of Otitela was planted, but may be a total loss due to a tropical cyclone. In Nampula, six varieties were planted on ¼ hectare for maintenance and breeder seed production (Otitela, JL-24, Nametil (ICG 12991), ICGV-SM 01513, ICGV-SM 01514 and ICGV-SM 99568); three genotypes that were submitted for release also were multiplied. In Balama, 1 hectare of JL-24 and 1 hectare of Nametil were grown.

Zambia: Five and a half acres of breeder seed were planted on the ZARI station near Chipata, and eight demonstration plots were planted at farmer training centers in eight districts of the Eastern province. The training centers host annual farmer field days that attract hundreds of farmers to learn about the new technologies and varieties across different crops.

Capacity Building

Twenty irrigation sprinklers and stands were replaced in Ghana. Additional irrigation was installed in Mozambique, irrigation water supply tanks were installed in Malawi, and a water storage tank was identified for purchase in Senegal.

Co-PIs discussed issues of regional trials, demand-led breeding and product profiles for varieties with colleagues from across Africa and the Advances in Arachis Genomics and Biotechnology Conference in Saly, Senegal at the Breeders Crop Network Groups for Africa meeting in Thies, Senegal.

A total of 127 farmers (42 females, 85 males) from Malawi, Uganda and Zambia were trained in quality seed production using good agronomic practices.

Lessons Learned

Country-wide seed demand needs to be determined well in advance to guide the seed production pipeline since it requires two to three years to produce sufficient seed when starting from quality foundation seed.

The demand for improved varieties is higher than the supply and there is need to reduce this gap as soon as possible.

Cold storage is a critical necessity of all breeding programs. The absence of cold storage will affect long term storage of the early generation seeds of the flagship varieties. This needs to be considered a high priority for capacity-building efforts.

Presentations and Publications
None to date.

SNP genotyping of African peanut germplasm

PI: Peggy Ozias-Akins, UGA, GA

Research Locations
ISRA-CERAAS, Thies, Senegal; University of Georgia, Tifton, GA, USA

Description
The project, commissioned at the beginning of the Peanut Innovation Lab, is genotyping a wide array of African peanut germplasm using the high-density, 48K Axiom_Arachis2 SNP array. The SNP array, recently created by a project led by the PI, allows the efficient detection of 30,539 SNPs (single nucleotide polymorphisms) in the peanut genome at a reasonable price per line. The array already has been used to genotype several peanut populations segregating for resistance to nematodes, tomato spotted wilt virus, late leaf spot, and white mold, and for several seed traits, as well as a set of lines used to screen for low aflatoxin contamination.

Genotyping diverse germplasm relevant to the Peanut Innovation Lab allows breeders to take advantage of the latest genetic technologies in peanut to catalog genetic diversity among breeding materials, identify genomic regions under positive or negative selection or alleles fixed in a breeding program, enable genome-wide background selection, identify a subset of polymorphisms to be developed for single-marker analysis for specific traits, and construct genetic maps of populations segregating for important traits.

Applying genomic information in peanut breeding will accelerate the incorporation of alleles for biotic and abiotic stress tolerance and seed quality traits resulting in a healthier and higher value crop.

Theory of Change/Impact Pathway(s)
Information on the genetic makeup of varieties allows breeders to broaden the diversity in their programs. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators
Daniel Fonceka, ISRA-CERAAS, Senegal

Achievements
From June to October 2018, a total of 1132 accessions were assembled, including 467 from West Africa (Ghana, Mali, Niger, Senegal and Togo) and 665 from East and Southern Africa (Malawi, Mozambique, Uganda and Zambia). Nearly half of the materials (47%) of materials originated from ICRISAT while 53% were from other sources.

Overall, 10% of accessions were nominated by more than one country. Among the ICRISAT materials, 42% of accessions were nominated by more than one country.

All accessions were grown in Senegal, leaves from a single plant per accession were harvested and DNA extracted. DNAs were sent to UGA and submitted to Affymetrix for genotyping using the Axiom_Arachis2 SNP array. The genotypes were determined using Axiom Analysis Software and the data analyzed at a workshop held in Senegal in June. Breeders from all participating countries were in attendance. Co-analysis of the three plates containing all genotypes was conducted from which a total of 8911 SNPs was reliably called. The clustering of genotypes was evaluated, and selections were made to represent all breeding programs and the extent of diversity. Specifically, each of the 10 breeding programs could nominate their top 10 lines, then the remaining lines in sets of 200, 250, and 300 were selected to represent genotypic diversity. Seeds from the selected lines will be increased and distributed to all participants participating in the phenotyping project.

Capacity Building

A partnership continues between Peggy Ozias-Akins and Ye Chu (UGA) and Daniel Fonceka (CERAAS) along with contribution from Josh Clevenger (Mars-Wrigley); partnerships are growing with CERAAS (Senegal), NaSARRI (Uganda) and other national programs participating in the project.

Peggy Ozias-Akins, Daniel Fonceka, and Josh Clevenger attended the international Advances in Arachis Genomics and Biotechnology held in Saly, Senegal, November 2018, where many discussions with current and future collaborators were held.

A workshop was conducted in Senegal in June 2019 involving the PIs, co-PIs and all breeders on data analysis using the SNP data. Participants were able to analyze their own materials and left the workshop with the analysis software and data installed on their laptop computer for use back home.

Lessons Learned

Some delay was encountered in completing DNA extractions due to the slow receipt of reagents in Senegal. Breeder participation and enthusiasm was phenomenal.

Presentations and Publications

Fonceka, D., Bertioli, D., Ozias-Akins, P., Kalule, D. O., Rami, J. July 2019. Mobilizing genetic diversity for strengthening peanut breeding program in Africa and the US. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Leveraging genetic resources to enhance peanut breeding in Africa and the US

PI: Peggy Ozias-Akins, University of Georgia, Tifton, GA

Research Locations

NARO-NaSARRI, Soroti, Uganda; ISRA-CERAAS, Thies, Senegal; University of Georgia, Athens, GA, USA

Description

The objective of this project is to genotype over 2600 accessions of African origin conserved in the USDA peanut germplasm collection, then to combine data with the genotypes generated from African breeding materials under the above project. The project is jointly funded with the Peanut Research Foundation, a US peanut industry supported foundation. Through a USDA NIFA-

sponsored project, 275 African accessions are being genotyped, and these data already have been provided.

Relatedness of these 2600+ lines to each other and to those in current African breeding programs will be determined from the genotypes, allowing breeders to make informed decisions on how to increase diversity in their programs.

Theory of Change/Impact Pathway(s)

Information on the genetic makeup of varieties allows breeders to broaden the diversity in their programs. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

Corley Holbrook, USDA-ARS, Tifton, GA, USA, Shyam Tallury, Plant Genetic Resources Conservation Unit, Griffin, GA; Jean-Marcel Ribaut, Integrated Breeding Platform, CIMMYT, El Batán Texcoco, Mexico; Ethalinda Cannon, Iowa State University, Ames, IA; Jean-Francois Rami, CIRAD, Montpellier, France

Achievements

A total of 2655 lines were obtained from the USDA collection, 1,644 were grown out in Tifton, GA and 842 are being genotyped using the Axiom_Arachis2 SNP array. To date, 775 of the accessions have been completed.

Capacity Building

Partnerships already established in the above project continue to be strengthened. The USDA peanut genebank is now part of this effort.

Lessons Learned

We overestimated our capacity to grow out the lines. Space has been an issue given parallel projects but was more than 60% complete at reporting time.

Presentations and Publications

Ozias-Akins, P. July 2019. Mobilizing Genetic Diversity for Strengthening Peanut Breeding Program in Africa and the US. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Integration of high throughput phenotyping (HTP) for enhancing breeding programs

PI: Maria Balota, Virginia Tech, VA

Research Locations

NARO-NaSARRI, Soroti, Uganda; CSIR-SARI, Kumasi, Ghana; KNUST, Kumasi, Ghana; CSIR-SARI, Tamale, Ghana; ISRA-CERAAS, Thies, Senegal; ISRA-CNRA, Bambey, Senegal

Description

Peanut yield and quality are low in much of Africa. Under the conditions of unavailable basic agricultural inputs, soils depleted of phosphorus and other essential plant nutrients, scarce precipitation, and high disease pressures, peanut production can be improved through the development of new cultivars with more efficient use of water and nutrients, and disease

resistance. Breeding efforts can benefit from the development of high throughput phenotyping tools using new, yet inexpensive, technologies and sensors.

The project objectives include: 1) developing high-throughput phenotyping (HTP) tools for field selection for disease, drought, and variety performance; 2) developing effective HTP systems to determine peanut maturity and oleic fatty acid content - necessary steps towards quality control in seed production; 3) enhancing the breeding capabilities in Africa by procurement and training on the use of relatively inexpensive sensors and the software needed to retrieve data; and 4) improving youth and gender awareness for the value of innovative plant breeding and variety development for increased regional food security by collaborating with 4-H Youth Clubs in Senegal and Ghana and the Youth Farmers Association of Uganda.

Theory of Change/Impact Pathway(s)

The ability to rapidly determine performance characteristics for large number of individuals allows breeders to better select the best lines. The phenotyping tools used in this project are being transferred to breeding programs through the joint project allowing them to utilize them in their research. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

Thomas Archibald, Virginia Tech, VA; David Kalule Okello, NARO-NaSARRI, Uganda; Richard Oteng-Frimpong, CSIR-SARI, Ghana; Richard Akromah, KNUST, Ghana; Daniel Fonceka, ISRA-CERAAS, and Issa Faye, ISRA-CNRA, Senegal

Achievements

Graduate students were recruited and enrolled in Ghana and Uganda.

HTP tools, including red-green-blue, near infrared, and infrared cameras, SPAD chlorophyll meters, chlorophyll fluorescence sensors, and MultispeQ sensors were purchased and delivered to Ghana, Senegal and Uganda. Initial training in their use was done in Uganda and Senegal by the PI.

In each country, peanut trials were planted, and measurements will start in late 2019 using the sensors to measure physiological effects of drought and groundnut rosette virus (GRV) infection. The best HTP methods to estimate yield under these stress conditions will be selected for each country and used in the future by breeders to expedite cultivar development in these countries.

Capacity Building

HTP tools have been provided to the national programs in Ghana, Senegal and Uganda. Training in their use and application to plant improvement is underway.

Lessons Learned

Purchase and delivery of equipment, as well as recruitment of graduate students, are time consuming processes, and the sooner they are started the better for the project.

Presentations and Publications

High Throughput Phenotyping, Sally, November 2018. Presentation at Advances in *Arachis* Genomics and Biotechnology Conference, Saly, Senegal.
High Throughput Phenotyping. May 2019. Presentation at Peanut Innovation Lab, Uganda Projects Launching Workshop, Kampala, Uganda.

Enhancing the genetic potential of peanut production in Eastern and Southern Africa

PI: David Okello, NARO- NaSARRI, Uganda

Research Locations

NARO-NaSARRI, Soroti, Uganda; DARS-Chitedze Research Station, Lilongwe, Malawi; ZARI, Chipata, Zambia; IIAM, Nampula, Mozambique; ISRA-CERAAS, Thies, Senegal

Description

The use of molecular markers to unlock the potential for more diversity in a contrasting panel of accessions for crop improvement is a proven and successful approach. Building on the drastic reduction of genotyping costs, and an increased analytical power over the last decade, GWAS is now a powerful approach for the genetic dissection of target traits and the identification of favorable alleles/genomic regions when these are present above a certain frequency in segregating populations. In peanut, genetic variations have mainly been identified and exploited, until now, by breeders using bi-parental populations because of the lack of polymorphism in the cultivated species, and of suitable and cost-effective genotyping technologies. Recent advances in peanut genomics – among which the sequencing of cultivated peanut and the development of a high-density genotyping Axiom_Arachis array with thousands of polymorphic SNP for cultivated peanut – open the way for high-throughput genotyping in peanut, allowing effective genetic dissection of target traits, and the identification of major genes and/or QTLs for marker-assisted breeding.

Using 200-300 accessions identified in collaboration with another project, will be tested across a range of environments and conditions in least four countries in Eastern and Southern Africa, and four in West Africa through Daniel Fonceka's project to generate relevant information and data around diversity and the genetic basis for target traits, leading to a broadening of the genetic base for peanut breeding programs, and the development of new genes/markers for molecular breeding. The overall objective of the project is to characterize and document a unique pool of material that can be used as a new source of germplasm and alleles to improve peanut breeding in Eastern and Southern Africa.

This coordinated effort across strong, existing networks will enable us to: 1) assess diversity and identify germplasm from the core panel to be introduced to national breeding programs to fill possible diversity gaps; 2) dissect the genetic control of target trait variation via association studies, and identify trait-linked markers for breeding purposes; 3) based on performance, identify potential new donor lines for local breeding programs; and 4) increase capacities for a vibrant network of peanut breeders in Eastern and Southern Africa to apply modern genetic approaches in breeding, and to collectively share and analyze data.

Theory of Change/Impact Pathway(s)

Information on the genetic makeup of varieties and use of core sets based on this information allows breeders to broaden the diversity in their programs. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators
Lutangu Makweti, ZARI, Zambia**;** Amade Muitia, IIAM, Mozambique**;** Justus Chintu, DARS, Malawi**;** Jean-Marcel Ribaut, IBP, Mexico**;** Peggy Ozias-Akins, UGA, GA**;** Daniel Fonceka, ISRA-CERAAS, Senegal

Achievements
Of 1049 genotypes of the African Collection, 953 lines were received from Senegal due to inadequacy of seed. Those lines were planted in 2019A, harvested and seeds prepared for 2019B planting at two locations, Nakabango-Jinja and Serere. They will be screened for leaf spots and groundnut rosette virus. A small portion will be multiplied under irrigation and protection in 2019B.

A PhD graduate student was enrolled at MaRCCI to do her thesis research on the project and will complete her course work in late 2019.

Capacity Building
The project has a strong link with IFAD-EBCA project on BMS usage (training, licensing) and co-funding a PhD student.

Lessons Learned
Institutional buy-in will lead to BMS being adopted and sustained in their Institutions. Continuous BMS usage is required to be up to date with its functionalities. Inclusion of a statistician in BMS training especially the data analyses and interpretation of the BMS is very helpful.

Social media can be used to build teams, e.g., the ESA breeders use a WhatsApp group to discuss BMS and groundnut breeding issues; and the NaSARRI teams have a WhatsApp group where they exchange BMS related issues in addition to running the breeding program.

Presentations and Publications
Ozias-Akins, P. Mobilizing Genetic Diversity for Strengthening Peanut Breeding Program in Africa and the US. July 2019. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Enhancing the genetic potential of peanut production in West Africa

PI: Daniel Fonceka, ISRA-CERAAS, Senegal

Research Locations
NARO-NaSARRI, Soroti, Uganda; CSIR-SARI, Tamale, Ghana; ISRA-CNRA, Bambey, Senegal; INRAN-CERRA Niamey, Niger; IER-CRRA, Bamako, Mali

Description
Africa is known to be a secondary center of diversity for cultivated peanut. Peanut breeders from different countries in Africa each hold small parts of this diversity individually which, put together, represent unique genetic resources that could be used to map traits of interest and add value to breeding programs. A panel of about 200-300 accessions will be tested across a range of environments and conditions (at least four countries in West Africa, and four in Eastern and Southern Africa through David Okello's project) to generate relevant information and data around diversity and the genetic basis for target traits, leading to a broadening of the genetic base for peanut breeding programs, and the development of new genes/markers for molecular

breeding. The overall objective of the project is to characterize and document a unique pool of material that can be used as a new source of germplasm and alleles to improve peanut breeding in West Africa.

The accessions will come from a set of 300 peanut lines from across Africa that will go through phenotypic and genotypic evaluation in Senegal and Uganda. The set will represent as much of the groundnut diversity across the African continent as possible but provide a set of a suitable size for multi-site evaluation in replicated trials. Breeders will evaluate this African core panel under local conditions in several countries in West Africa, including Ghana, Mali, Niger and Senegal.

Core panel performance will be evaluated running single and multi-environments (GxE) analysis from phenotyping data. Diversity analysis, bringing together phenotypic and genotypic data from this very diverse set of African accessions, will allow for a better understanding of the genetic diversity used by each breeding program in West Africa, and thus provide breeders with opportunities to enlarge the genetic pool of material they use as parental lines for new crosses. The same set of data will also allow genome-wide association studies (GWAS) to be run which will identify the genomic regions involved in the expression of target agronomic traits within a single environment, and across comparable ones. For simple inherited traits, association analysis could result in the identification of trait-linked markers that would be, after validation, suitable for forward breeding or allelic introgression. Genomic regions of interest for further gene pyramiding will also be identified for quantitative traits. Considering the performance of the core panel, some accessions performing well under specific local conditions might be considered as suitable donor lines for new crosses, or even ready to go directly into the national registration process.

Theory of Change/Impact Pathway(s)

Information on the genetic makeup of varieties and use of core sets based on this information allows breeders to broaden the diversity in their programs. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

Issa Faye, ISRA-CNRA, Senegal**;** Richard Oteng-Frimpong, CSIR-SARI, Ghana**;** Adama Coulibaly, INRAN-CERRA, Niger**;** Dramane Sako, IER-CRRA, Mali**;** Jean-Marcel Ribaut, IBP, Mexico**;** Peggy Ozias-Akins, UGA, GA

Achievements

A collection of 1050 genotypes from 10 breeding programs in Africa was assembled, genotyped and multiplied. Diversity analysis showed that there is no clear structuration of the genetic diversity based on geographic origin of the material.

Three core sets of lines (100, 200 and 300 lines) were identified to deal with the breeders' capacity of handling a huge number of lines in their phenotyping experiments.

Breeders have been exposed to the SNP and diversity analysis software. All scripts used during the workshop for the analysis were shared with breeders to allow them to reproduce the analyses by their own means.

Capacity Building

The project strengthened the partnership between five peanut breeding programs in West-Africa (Ghana, Mali, Niger and Senegal) and between these breeding programs and the ones in East

Africa (Uganda) and Southern Africa (Malawi, Mozambique, Zambia). Moreover, the young breeding program of the Republic of the Gambia has been invited to join the regional dynamic and be exposed to the modern genomic tools available in peanut. This project is also aligned with the IFAD-funded EBCA project led by IBP, which involves the peanut breeding program of Ghana, Senegal and Uganda.

Lessons Learned

Gaining breeders' commitment to share germplasm and information is one of the key success of the project.

Training is needed for breeders to really take advantage of the SNP data produced.

Presentations and Publications

None to date.

Use of novel genetic diversity for peanut varietal development in East Africa

PI: Soraya Leal-Bertioli, UGA, GA

Research Locations

NARO-NaSARRI, Soroti, Uganda; ISRA-CERAAS, Thies, Senegal; University of Georgia, Athens GA, USA

Description

In this project, wild relatives of peanut are being tapped to provide new alleles to improve cultivated species to have resistance to components of leaf spots and groundnut rosette disease (GRD). New lines containing some of these wild species are available at UGA and will be tested in Uganda. Three wild-derived advanced populations and several lines with resistant alleles have been produced in CERAAS (Senegal), and they will also be available for testing in Uganda. Selected, resistant progenies will be crossed with preferred peanut lines for the production of cultivars with higher levels of resistance to leaf spots and GRD.

Theory of Change/Impact Pathway(s)

Access to new and diverse germplasm allows breeders to broaden the diversity in their programs. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

David Kalule Okello, NARO-NaSARRI, Uganda**;** Daniel Fonceka, ISRA-CERAAS, Senegal**;** David Bertioli, Mike Deom, Rajagopalbabu Srinivasan, Scott Jackson, Peggy Ozias-Akins, UGA, GA; and Josh Clevenger, Mars-Wrigley/UGA, GA

Achievements

The following materials were transferred to Uganda:

- 130 AB-QTL lines from the cross (Fleur11 x (*Arachis batizocoi* x *A. duranensis*)4x) developed in Senegal by the group led by the co-PI Daniel Fonceka.
- A total of 200 seeds from 26 *A. diogoi* derived advanced peanut lines developed at North Carolina State University by Tom Stalker that contain superior resistance to fungi or viruses.

- Eight newly formed allotetraploids derived from wild species of peanut: (four events from *A. ipaensis* x *A. duranensis*)4x, three events from (*A. ipaensis* x *A. correntina*)4x, and one event from (*A. batizocoi* x *A. duranensis*)4x.
- 200 AB-QTL lines from the cross (Fleur11 x (*A. valida* x *A. dur*anensis)4x) developed in Senegal by the group led by the co-PI Daniel Fonceka.

Initial field evaluation was done for the AB-QTL lines from the crosses Fleur11 x (*A. valida* x *A. duranensis*)4x) and (Fleur11 x (*A. batizocoi* x *A. duranensis*)4x), and CSSL lines from the cross (Fleur11 x (*A. ipaensis* x *A. duranensis*)4x) transferred from Senegal and allotetraploids and *A. cardenasii*-derived advanced lines transferred from USA.

Capacity Building

New materials have been transferred to the national program in Uganda and are available for use in developing new varieties. Graduate students are enrolled and mentored.

Lessons Learned

The team in Uganda is excellent and very committed to the success of the project. This has made it easier to deal with delays in funding and to ensure that all activities were implemented as required. Conducting the startup meeting in Uganda was extremely helpful in launching the project and developing the students' thesis projects.

Presentations and Publications

None to date.

Incorporating new wild alleles to improve elite West African peanut cultivars

PI: David Bertioli, UGA, GA

Research Locations

ISRA-CERAAS, Thies, Senegal; University of Georgia, Athens, GA, USA

Description

Genetic variation in peanut is limited due to its recent, unique, polyploid origin, which limits crop improvement through breeding. Wild relatives of peanut are a rich source of alleles that have arisen over millions of years of natural selection in diverse environments. However, in early generation hybrids, the valuable wild alleles are masked by the more numerous unfavorable wild alleles that confer poor growth habit, small seed size, etc. These "cryptic" favorable wild alleles can be discovered through multiple cycles of backcrossing and screening for favorable traits when the wild alleles are incorporated with a substantially cultivated peanut genetic background.

Previous projects using this strategy have developed varieties that are resistant to late and early leaf spot. Advanced backcross populations have been completed or partially developed. Positive cryptic alleles have been discovered. From the first highly backcrossed population, six new varieties were released in Senegal – with improved yield stability, haulm mass, higher yield and larger seeds. The proposed work will build on these successes, evaluating a previously developed set of lines and laying the foundation for the production of new ones. Promising lines will be tested for cultivar release and/or incorporated into breeding programs. Materials produced will form a publicly available resource.

Theory of Change/Impact Pathway(s)

Access to new and diverse germplasm allows breeders to broaden the diversity in their programs. This results in more resilient varieties being delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

Daniel Fonceka, ISRA-CERAAS, Senegal**;** Soraya Leal-Bertioli, Scott Jackson and Peggy Ozias-Akins, UGA, GA

Achievements

Completed 18 cross combinations of three accessions of the B genome wild species *Arachis magna* (K30097, K30092 and V13752) and three accessions of *A. hoehnei* (V9094, V9140, PI666086); 143 potential hybrid pegs produced, and colchicine treatment of a previously made diploid hybrid *A. magna* 30092 x *A. diogoi* 10602 has resulted in a tetraploid hybrid that is currently flowering.

Transferred the following material to Senegal:

- CS-16 advanced peanut line containing 3 chromosome segments from the wild species *A. cardenasii* which confer resistance to late leaf spot and rust;
- [*A. batizocoi* K9484 x *A. stenosperma* V10309]4x peanut compatible wild species derived allotetraploid harboring multiple disease resistances
- [*A. ipaensis* K30076 x *A. correntina*]4x peanut compatible wild species derived allotetraploid harboring multiple disease resistances
- Two AB-QTL populations, Fleur11 x Batdur and Fleur11 x Valdur, were advanced to the next generation and seed produced for future field evaluation.

Transferred the following material from Senegal to other African countries:

- CS-16 line sent to Mali, Niger, Togo, Burkina Faso, Ghana, Uganda, Mozambique, Malawi and Zambia
- 130 AB-QTL lines from the cross between Fleur11 x Batdur and 200 AB-QTL lines from the cross between Fleur11 x Valdur sent to Uganda.

Capacity Building

This project is giving the opportunity of strengthening the existing partnership between the PI and co-PIs, providing new diversity for breeding programs and building capacity in these programs to analyze and utilize such materials.

Lessons Learned

African programs are very interested to receive new diversity and crosses from the wild species.

Presentations and Publications

Bertioli, D. July 2019. International collaboration leverages peanut research and crop improvement. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Developing *Aspergillus flavus*-resistant peanut using seed coat biochemical markers

PI: Venugopal Mendu, Texas Tech University, TX

Research Locations

ICRISAT, Niamey, Niger; ICRISAT, Patancheru, India; Texas A&M University, Lubbock, TX, USA

Description

The project studies the development of the seed coat of peanut and whether increasing naturally occurring biochemicals in the seed coat can increase the resistance to *Aspergillus flavus*, the fungus that can produce aflatoxin. The aim of the project is to fortify the seed coat with cell wall/antimicrobial compounds to confer pre- and post-harvest *A. flavus* resistance in peanut. Specific objectives of the project are to: 1) discover seed coat biochemical(s) associated with *A. flavus* resistance; 2) develop biochemical Marker Assisted Selection (bMAS) pipeline for breeders in target countries, and 3) develop *A. flavu*s resistant line(s) for field deployment in target countries.

Theory of Change/Impact Pathway(s)

The information gained from the research will allow researchers to identify lines that have new resistance to pathogen infection and reduced mycotoxin contamination. These lines can be used by breeders to develop more resilient varieties and release these to farmers. Use of the new varieties as food and feed will reduce the effects of mycotoxins to human and animal health.

Collaborators

Mark Burow, Texas Tech University, TX**;** Hamidou Falalou, ICRISAT, Niger**;** Hari Sudini, ICRISAT, India

Achievements

Obtained and planted 11 lines from the USDA germplasm collection with different seed coat color in the field for seed. In addition, a Senegal *A. flavus* resistant genotype (73-33) has been obtained and planted in the green house for seed increase. All these lines will be tested using *in-vitro* seed colonization (IVSC) and biochemical assays.

Planted 55437 and TMV2 for seed increase and to make crosses in the field.

The advanced breeding population (F4) from the cross 55437 X TxL054520-27 were planted in the field. These lines will be used for biochemical analysis and IVSC studies.

Planted and harvested seeds from 33 ICRISAT genotypes in India for IVSC testing *A. fla*vus infection and subsequent aflatoxin contamination. Two trials planted: one in the field (25 lines, 4 replications, 2 water regimes) and one in the lysimeter facility (10 lines, 5 replications, 2 water regimes).

Identified presence of pro-anthocyanidins (soluble and insoluble), total lignin and lignin monomers (G, S and H) from peanut seed coat.

Identified the peanut genes involved in the biochemical production using *Arabidopsis* homologues and designed primers.

Phenolic compounds were extracted from 55-437 peanut seeds and determination of its effect on the growth of *A. flavus in-vitro*.

Capacity Building

Aminou Adamou Maman Mouta was recruited in January 2019 to work on this seed coat biochemical project for Ph.D. program (ICRISAT, Niger). He is registered at the University Abdou Moumouni, Niamey, Niger. He is expected to complete his degree by March 31, 2022.

Heynikoye Mariama was recruited in May 2018 to work on this seed coat biochemical project for Ph.D. program (ICRISAT, Niger). She is registered at the Ado Bayero University, Nigeria. She is expected to complete her degree by April 1st, 2021.

Leslie Commey was recruited from Ghana in August 2019 to work on this seed coat biochemical project (Texas Tech University, Lubbock). He is expected to complete his MS program by August 31, 2021.

Lessons Learned

The PI has learned about managing funding and sub-awards, as well as how to coordinate field work in three different countries, including germplasm collection, maintenance and seed increase.

Presentations and Publications

Mendu, V., Burow, M., Falalou, H., Sudini, H., Tengey, T. April 2019. Developing *Aspergillus flavus* resistant peanut using seed coat biochemical marker(s). Presentation at 2019 Peanut Innovation Lab Ghana PI Meeting, Raleigh, NC

Pandey, M. K., Pandey, A. K., Soni, P., Gangurde, S. S., Sudini, H. 2019. Mitigating aflatoxin contamination in groundnut through a combination of genetic resistance and post-harvest management practices. Toxins 11:1-21. doi:10.3390/toxins11060315.

Mapping Groundnut Rosette Virus (GRV) resistance for marker-assisted selection

PI: Josh Clevenger, Mars Wrigley Confectionary/UGA, GA

Research Locations

NARO-NaSARRI, Soroti, Uganda; DARS-Chitedze Research Station, Lilongwe, Malawi; ICRISAT, Nairobi, Kenya; University of Georgia, Athens, GA, USA

Description

Groundnut rosette disease caused by the Groundnut Rosette Virus (GRV) complex is the most destructive peanut disease in sub-Saharan Africa. Resistance has been introduced into locally grown varieties and is a perfect target for genomics-assisted selection to effectively integrate resistance into future varieties. The genetic mapping resources are available for marker development, but the capacity to develop a marker tightly linked to resistance needs to be developed and implemented using the latest genomics technology and expertise.

The project will develop diagnostic molecular markers that can be used to select for GRV resistance using existing RIL populations that are segregating for resistance to GRV, but not the virus vector. We will combine strong phenotypic data with classical QTL mapping using high density SNP markers from the Axiom_Arachis2 SNP array. In addition, we will carry out QTL-seq analysis using bulked tails of the phenotypic distribution. This analysis will provide

population-specific markers as well as whole genome selection for the resistant parent, ICGV-SM 90704. Markers will be evaluated in GRV hotspots in Malawi and Uganda. Additional results will be accrued from association analysis of an African diversity set that is being screened in Uganda as part of another initiative led by David Okello and Daniel Fonceka. The total effort is expected to produce strongly linked marker(s) to GRD resistance that can accessibly be deployed in breeding programs in collaboration with Intertek genotyping services. The marker(s) will be used to select efficiently for resistance so that other high value traits can be introgressed into locally adopted varieties for rapid genetic improvement.

Theory of Change/Impact Pathway(s)

Tools to select for resistance to GRV will allow breeders to develop more resistant varieties. These varieties can then be delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

Damaris Odeny, ICRISAT, Kenya; Peggy Ozias-Akins, UGA, GA; David Okello, NARO-NaSARRI, Uganda

Achievements

The mapping population segregating for GRV resistance was genotyped using the SNP array. In total, 262 RIL lines plus parents were genotyped. These DNA are saved in Tifton, GA for future work and represent the "cleaned" population that is being used in the current study. In addition, DaRT sequencing of the same lines was analyzed to add an additional 400 sequence-based markers.

Analysis of the population and parents reveals ambiguity in the parentage of the population. In short, a very small percentage of markers segregated in the parents. In some cases, multiple sources of one parent segregated for many of the markers and shared alleles with the susceptible parent. Because we cannot reliably assign "parental" alleles, the analysis of the population will have to be done using QTL-seq.

A preliminary analysis of the 2013 phenotypic data set using an array-based bulk segregant analysis revealed two regions where markers segregated with disease scores. The population was planted for field rating in Malawi. A glasshouse experiment was planned, but the National Program did not allocate enough space for it to be carried out.

In parallel to the field experiment this year, a seed increase block was planted so that there is enough seed to send to David Okello in Uganda and test in the field in 2020 and the glasshouse.

Capacity Building

None to date.

Lessons Learned

This year was smooth in terms of getting DNA sent to Georgia for genotyping.

Presentations and Publications

None to date.

Breeding for tolerance to water deficit, resistance to leaf spot and improved oil composition in peanut

PI: Mark Burow, Texas A&M University, TX

Research Locations

CSIR-SARI, Tamale, Ghana; ISRA-CNRA, Bambey, Senegal; Texas A&M University, Lubbock, TX, USA

Description

Water deficit stress and leaf spots are two of the major contributing factors to the yield deficit of peanuts in Africa. This project enhances genetic diversity of peanuts to reduce the impacts of these stresses through the use of wild species, genetic populations generated in the USA and West Africa, and selected ICRISAT breeding lines. Genes for tolerance to water deficit, resistance to leaf spots, and enhanced oil composition will be transferred to breeding programs in Ghana and Senegal and used to develop improved varieties. DNA markers will be identified for tolerance to water deficit stress and resistance to leafspots. DNA markers will be shared with national programs and training provided for use in selecting for these traits and for the high oleic acid content. Multi-location trials will be conducted with the goal of identifying release candidates for new varieties.

Theory of Change/Impact Pathway(s)

The use of tools to select from better yield under drought and pest pressure results in more resilient varieties being developed by breeders and delivered to farmers, increasing yields, and ultimately improving household food security.

Collaborators

Charles E. Simpson, Texas A&M, TX**;** Richard Oteng-Frimpong, CSIR-SARI, Ghana**;** Issa Faye, ISRA-CNRA, Senegal

Achievements

Water deficit stress

A crossing program in spring 2019 for chromosome doubling attempts of the *A. dardani* derived cross saw heavy pest infestation, little flowering, and no fertilization. A fall crossing program was planted.

To develop MAGIC populations, initial crosses have been made in Ghana.

In Senegal, a RIL population Fleur 11 (Spanish) x 73-30 (drought tolerant with fresh seed dormancy) is being evaluated at Bambey for yield and yield-component traits.

Sequencing resulted in identification of ca. 130,000 SNPs, reduced to ca. 8,000 SNPs with high read depth across accessions.

Tolerance to leaf spots

Evaluations of F4 lines were conducted in 2018 in Ghana and evaluations are still on-going. Two SSR-based QTLs, PM3 and PMc348 have been validated.

185 lines from the cross of Nkatiesari and Schubert and a sister line were evaluated for reaction to early leaf spot diseases and pod characteristics at Nyankpala, Ghana and at the CSIR-CRI station at Fumesua for tolerance to leaf spots and pod yield. Fifty and 66 lines were selected. In

Senegal, a population developed from a cross between ICGV 96894 (55% oil, resistant to rosette, early and late LS) and 73-30 (drought tolerant with fresh seed dormancy) is being evaluated for yield and yield-components traits.

Genomics

We have conducted a study of the high rate of apparent heterozygotes and identified methods to reduce this. The third generation (F4) of the single seed descent B genome population was grown, evaluated, and harvested to be utilized in the molecular mapping project.

Documents for release of the peanut variety SARINut 1 in Ghana were submitted and approved. SARINut 1 is a leafspot-resistant runner peanut cultivar, the first high-oleic cultivar release in Africa.

Capacity Building

Training in the use of molecular markers and analysis of high-oleic content is planned for partners in Africa.

Lessons Learned

We have learned that the chromosome doubling of the *A. dardani* hybrids is much more difficult and challenging that we expected. We continue to anticipate that we will accomplish the doubling as we learn more about the handling of extremely wide hybridizations in the genus *Arachis*.

Presentations and Publications

Tengey, T., Simpson, C., Denwar, N., Sankara, P., Hillhouse, A., Mendu, V., & Burow, M. July 2019. QTLs for leaf spot resistance, yield, and maturity in an interspecific peanut introgression population in West Africa and Texas using KASP markers. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Simpson, C. July 2019. Tracking Development of Two Seeded Pods in Arachis Monticola Krapov. & Rigoni by Advancing Generations. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Burow, M., Oteng-Frimpong, R., Faye, I., & Simpson, C. July 2019. Breeding and Enhancement of Resistance to Leaf Spot, Tolerance to Water Deficit, and Improved Oil Composition in Groundnut. Presentation at Peanut Innovation Lab Ghana Projects Launching Workshop, Tamale, Ghana.

Burow, M., Denwar, N., Oteng-Frimpong, R., Sankara, P., & Bertin, Z. April 2019. PMIL West Africa/Texas Breeding and Genetics Report and Lessons Learned. Presentation at 2019 Peanut Innovation Lab PI Meeting, Raleigh, NC USA.

Burow, M., Oteng-Frimpong, R., Faye, I., Asibuo, J. Y., & Simpson, C. April 2019. Breeding and Enhancement of Tolerance to Water Deficit, Resistance to Leaf spot, and Improved Oil Composition in Peanut. Presentation at 2019 Peanut Innovation Lab Ghana PI Meeting, Raleigh, NC.

Cason, J. M., Simpson, C., Rooney, W. L., & Brady, J. A. 2019. Drought tolerant transcription factors identified in *Arachis dardani*. Agrosystems Geosciences and Environment.

Value-Added Gains Project Reports

Updating of the NCSU Risk Index Tool

PI: David Jordan, NCSU, NC

Research Locations
NCSU, Raleigh, NC, USA

Description
The main objective of this commissioned project is to modify the existing web-based North Carolina State University (NCSU) risk index software tool into a form that can be used in other US states and Peanut Innovation Lab countries to help farmers make informed decisions about production practices, including disease and pest management. The tool currently is designed specifically for the Virginia-Carolina peanut region but will be updated to allow extension specialists and others to more easily input of the data required for decision-making, thus making the tool available to use in other countries.

Theory of Change/Impact Pathway(s)
The risk tool is intended to be used by extension agents and farmers to determine the best options for the upcoming cropping season. Successful use of the tool would result in increased and more profitable yields for farmers.

Collaborators
Gail Wilkerson, Rick Brandenburg, Greg Buol and Barbara Shew, NCSU, NC

Achievements
The web-based NCSU peanut risk decision aid has been updated and now implemented within a Microsoft Excel workbook (https://agroclimatenc.ncsu.edu/peanut/riskmgmt). The Excel version has been designed to allow developers to adapt the NCSU design for new locations and to modify those decision aids without having to change program code.

The workbook is composed of several worksheets and Excel user forms. The main risk sheet allows users to select various production practices and see how the selected practices may influence the risk pests pose to crop yield. A second sheet, the pest data sheet, defines those pests. A third sheet contains information on production practices and options.

The remaining step is to link economic costs with management practices. Following that step, the tool will be ready for testing and use in other Peanut Innovation Lab project countries.

Capacity Building
None to date.

Lessons Learned
We don't know all that we could about how pests react under certain conditions. That knowledge is important to the risk tool.

Presentations and Publications
Buol, G. July 2019. Modification of the Peanut Risk Tool Developed at North Carolina State University. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

GRD alternative host

PI: Mike Deom, UGA, GA

Research Locations
NARO-NaSARRI, Soroti, Uganda; NARO-NaCRRI, Kampala, Uganda; University of Georgia, Athens, GA, USA

Description
The objective of this project is to identify alternate host(s) of groundnut rosette disease, which is the most destructive viral disease of groundnut in sub-Saharan Africa. This project will analyze possible hosts from major groundnut producing areas in Uganda where the disease occurs at a high incidence each growing season to accomplish this objective.

Theory of Change/Impact Pathway(s)
Groundnut rosette virus only exists in Africa although the aphid vector of the diseases exists in many of part of the world and most peanut varieties are susceptible. Identification of the alternate host would allow researchers to develop more sustainable strategies to maintain high levels of resistance to the disease. Such knowledge would also identify strategies for restricting migration of the disease to countries outside of Africa. Reducing the risk creates more sustainable yields globally.

Collaborators
David Kalule Okello, NARO-NaSARRI; Michael Hilary Otim, NARO-NaCRRI, Uganda**;** Paul Severns, UGA, GA

Achievements
A survey of possible alternative host for GRD was conducted in groundnut growing regions in Uganda. Samples of plants that might be infected with GRV were collected and will be sent to the PI's lab at the University of Georgia for molecular analyses to confirm the presence of GRV.

Capacity Building
None to date.

Lessons Learned
None to date.

Presentations and Publications
None to date.

Optimized Shrub System (OSS): an innovation for landscape regeneration and improved resilience for the peanut-basin of Senegal

PI: Dick Richard, The Ohio State University, OH

Research Locations
University of Thies, Thies, Senegal; ISRA-CNRA, Bambey, Senegal, The Ohio State University, OH, USA

Description
This project aims to further refine and overcome challenges to adoption of the Optimized Shrub System (OSS), which increases the density of native shrubs purposely planted in farmers' fields

and incorporates shredded shrub material into the soil, resulting in yield stability in the face of drought, improved soil fertility and resilience of the peanut/millet cropping system.

The project involves participatory surveys and focus sessions to gather information and design local adaptations to the OSS, measuring the effectiveness of OSS adoption by conducting on-farm trials with 20 households, researching peanut varieties best adapted for OSS, and conducting outreach.

Theory of Change/Impact Pathway(s)

A better understanding of the limits to adoption may help provoke new strategies to achieve widespread adoption of the shrub system. The increased density of the shrub system shows evidence of improved resilience to drought and yield improvements.

Collaborators

Ibrahima Diedhiou and Idrissa Wade, University of Thies, Senegal**;** Issa Faye and Alfred Tine, ISRA- CNRA, Senegal**;** Mark Erbaugh and Amanda Davey, Ohio State University, OH

Achievements

A focus session was held in November 2018 with farmers' cooperatives, NGOs and national extension agency, ANCAR. The session covered four themes: soil degradation in the northern peanut basin, experiences and/or sustainable practices used to improve agricultural productivity, perceptions of the role of shrubs in improving agricultural productivity, and the role of women in the peanut value chain.

Fifteen farming households in the southern and 15 households in the northern growing regions were recruited and trained in OSS for peanut/millet production.

A massive effort on the part of the ENSA team resulted in enough shrub seedlings to provide each of the 30 households with seedlings for their fields.

One PhD and two master's students have been recruited and started their training.

The baseline survey – including the Project Level Women's Empowerment in Agriculture Index and the Peanut Value Chain Gender Analysis and Soil Health Perception Survey – were finalized. In addition, protocols for bio-physical and socio-economic monitoring of the 30 households and their field plots have been finalized.

Development of the design of the shrub shredder is underway. Field trials and assessment by OSU Extension Specialist Brad Bergefurd in Senegal took place in July.

Capacity Building

Farmer's Cooperative - L'UGPM is our partner for the northern peanut basin households trials using *Guiera senegalensis*, and SYMBIOSE is our NGO partner for the southern household site using *Piliostigma reticulatum*. Other NGOs that were engaged in the past year are Green Senegal Agrécol Afrique, and Fédération Nationale de l'Agriculture Ecologique biologique (FENAB). On-going collaborations continued with ISRA, ANCAR, and the University of Thies.

Lessons Learned

A preliminary lesson learned (which may change as the project progresses) is that adoption of OSS seems to be more eagerly embraced in total by a farmer's cooperative in the northern basin over an NGO in the southern basin. It may be the case that this is because the level of soil degradation and threat of drought is more severe in the farmer's cooperative agroecological zone,

but it also may be the nature of cooperatives when the commit to a management practice they are all in.

Another major lesson learned is how difficult it is to mass produce shrub seedlings in a short period of time. This difficulty has resulted in innovations in shrub propagation by the ENSA team led by PI Ibrahima Diedhou. This lesson also highlights the great potential of seedling nurseries as an income generation activity.

Presentations and Publications
None to date.

Peanut production packages for Ghana

PI: David Jordan, North Carolina State University, Raleigh, NC

Research Locations
CSIR-SARI, Tamale, Ghana; CSIR-CRI, Kumasi, Ghana; KNUST, Kumasi, Ghana

Description
Peanut yields continue to be low in Ghana compared with those of other countries where new technologies and resources are available to farmers. Food safety through aflatoxin contamination is also compromised in Ghana because of poor drying and storing techniques. Previous research through the Peanut CRSP and PMIL focused on variety development, integrated pest management, and aflatoxin reduction throughout the peanut value chain. Deployment of new technologies in Ghana has been effective in some areas but continues to be limited across the country. A major challenge is a weak national seed supply chain that can deliver improved varieties and production packages that can increase yield, quality and farmer income.

To address these and other important issues facing farmers and the agriculture sector associated with peanut, this project is focused on four objectives: improving and scaling-up production packages that improve peanut production and quality, evaluating peanut-cereal cropping intensity and sequence to promote increased income and food security, developing and deploying a risk tool for peanut production, and improving linkages among public and private sector partners along the peanut value chain. Through these four objectives a framework for collaboration among partners in Ghana will be fostered, farmers will receive pertinent information that will enable them to increase yield and improve food safety, and human capacity will be enhanced.

Theory of Change/Impact Pathway(s)
Adoption of technologies that improve peanut production is limited due to access to inputs, such as improved varieties, but also lack of knowledge about cost/benefits of technologies as presented as packages. This research will generate and share knowledge related the package-based approach that may help improve productivity.

Collaborators
Rick Brandenburg, North Carolina State University, Raleigh, NC; Moses Brandford Mochiah, CSIR-Crops Research Institute, Kumasi, Ghana; Mumuni Abudulai, CSIR-Savanna Agricultural Research Institute, Tamale, Ghana; Richard Akromah, Nkrumah University of Science and Technology (KNUST), Kumasi, Ghana; Greg MacDonald, University of Florida, Gainesville, FL; Maria Balota, Virginia Tech, Suffolk, VA

Achievements

The Ghana Groundnut Working Group (GGWG) met for the first time in July to explore peanut production, economics, technology and benefits in Ghana. The Innovation Lab helped organize the meeting and springboard off another research meeting taking place the same week but was led by Ghanaian co-PIs and collaborators. The GGWG brought together more than 50 scientists and agricultural professionals from the Council for Scientific and Industrial Research, University Developmental Studies, private industry and foreign partners. The group met at the Modern City Hotel in Tamale.

A steering committee is in the process of developing a program and strategy for gaining a broader audience for the second meeting planned in early 2020.

Capacity Building

The first Ghana Groundnut Working Group meeting was held in July 2019 in Tamale with approximately 50 participants representing the groundnut industry in Ghana.

Lessons Learned

Increasing participation in the GGWG will be essential for success in improving the groundnut industry in Ghana. Additional efforts are needed to ensure inclusiveness across all disciplines and sectors of the groundnut supply chain so that key issues can be addressed effectively.

Presentations and Publications

Jordan, D. L. and Brandenburg, R. July 2019. Value of International Projects to Faculty in the United States: Examples of Participation by Individuals at North Carolina State University with the Peanut Innovation Lab. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Mochiah, B. July 2019. Summary of Interventions to Minimize Aflatoxin Contamination in Ghana at Pre- Harvest and Post-Harvest Steps in the Supply Chain. Presentation at 51st American Peanut Research and Education Society Annual Meeting, Auburn, Alabama.

Owusu-Akyaw, M. 2019. Evaluation and release of two peanut cultivars: a case study of partnerships in Ghana. Peanut Science 46:37-41. doi:10.3146/PS18-16.1.

Satellite image analysis for peanut

PI: Rick Brandenburg, North Carolina State University, Raleigh, NC,

Research Locations

Pyxus International, Lilongwe, Malawi; Stanford University, Stanford, CA, USA

Description

This project assesses the potential for using satellite imagery to determine a number of important cropping components for peanuts in smallholder farms. The information gained from satellite imaging could ultimately be linked with the decision risk tools to improve decision making and the deployment of actions to maximize yields and minimize aflatoxin contamination. GPS field coordinates, along with yield and crop quality data from several hundred smallholder farms, will be submitted annually to collaborators at Stanford University for analysis of satellite images to estimate plant responses to achieve the project's objective of assessing the potential benefit of using satellite imagery.

Theory of Change/Impact Pathway(s)
The field data collected and analysed may offer a wide array of applications if remote sensing data is proven accurate enough to detect the various crops and potentially their health and yield, including crop forecasting estimates, index insurance, impact analysis of programs, etc.

Collaborators
David Jordan, North Carolina State University, Raleigh, NC; David Lobell, Stanford University, Stanford, CA; Jeremy Venable, Malawi Agricultural Diversity Project, Lilongwe, Malawi; Dominic Reisig, North Carolina State University, Raleigh, NC; Wezi Mhango, Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi

Achievements
An initial dataset of GPS locations of groundnut fields has been provided by Pyxus and is being analyzed by David Lobell's lab.

Capacity Building
Extension workers in Malawi who will be collecting data for the project were trained on measuring GPS locations of fields and final yields.

Lessons Learned
Collaborators and cooperators require a written commitment and funding to complete work.

Presentations and Publications
None to date.

Peanut production packages for Malawi

PI: Rick Brandenburg, North Carolina State University, Raleigh, NC

Research Locations
DARS-Chitedze Research Station, Lilongwe, Malawi; LUANAR, Bunda, Malawi; Horizon Farms, Lisungwe, Malawi

Description
This project develops profitable and sustainable peanut production practices that combine inputs and interventions to increase yield, quality and profitability for smallholder and more commercial farmers. This project will develop packages of proven technologies and evaluate them across recently released cultivars.

Specific objectives of the project are to: 1) develop production packages that optimize smallholder farmer productivity, quality and profitability; 2) publish and disseminate a production and management guide for peanut production in Malawi and surrounding countries; and 3) build capacity in Malawi through the training of MSc students and conducting training workshops in peanut production.

Theory of Change/Impact Pathway(s)
Adoption of technologies that improve peanut production is limited due to access to inputs, such as improved varieties, but also lack of knowledge about cost/benefits of technologies as presented as packages. This research will generate and share knowledge related the package-based approach that may help improve productivity.

Collaborators
David Jordan and Dominic Reisig, North Carolina State University Raleigh, NC; W. Mhango, Lilongwe University of Agriculture and Natural Resources, Lilongwe, Malawi; Jeremy Venable, Malawi Agricultural Diversification Activity, Lilongwe, Malawi; Andrew Goodman, Horizon Farming Ltd, Lisungwe, Malawi

Achievements
This project began in October 2019 and there are no activities to report other than planning. A site visit is scheduled for November 2019 to finalize research trials and subcontracts and funding transfers are underway.

Capacity Building
None to date.

Lessons Learned
None to date.

Presentations and Publications
None to date.

Nutrition Project Reports

Regulation of gut microbiome by peanut supplements in youth

PI: JS Wang, University of Georgia, Athens, GA

Research Locations
Makerere University, Kampala, Uganda; University of Georgia, Athens, GA, USA

Description
This project studies the specific roles peanuts play in improving nutrition and health status in growing children by regulating their gut microbiota by investigating how a peanut snack affects the gut microbiome and microbial metabolisms in 6- to 9-year-old boarding school children of both genders in Mukono district in Uganda. We will use the next-generation sequencing and high-throughput analytical techniques to perform metagenomics and metabolomics analysis to assess the regulatory effects of peanut consumption on the structure and function of gut microbiome in healthy children. Preliminary analysis of both urine and stool samples will be conducted in Makerere University's College of Health Sciences, while advanced genomic and metabolomics analysis will be done at the University of Georgia in the US.

A baseline cross-sectional survey will be conducted in two primary schools to assess the household characteristics as well as nutritional and health status of the children. One of the schools will be randomized as the control and the other as the intervention. Over 90 days, one group of 48 students will receive salted peanuts, while 48 students do not receive peanuts.

Growth parameters, such as weight and height, will be measured every 15 days. Fecal and urine samples will be collected at the same time for microbiome and metabolomics analysis. The research will explore the significant difference on growth parameters between children who regularly consume peanut snacks and those children who rarely consume peanut/peanut-based

meals, as well as variations on peanut effects between males and females based on microbiome and metabolomics outcomes.

Theory of Change/Impact Pathway(s)
The impact of peanut consumption on the gut microbiome may increase peanut consumption.

Collaborators
Lili Tang, University of Georgia, Athens, GA; John Ssempebwa and Geofrey Musinguzi, Makerere University School of Public Health, Kampala, Uganda.

Achievements
Afield study team, established with Makerere University School of Public Health collaborators, visited three schools in different districts and selected study sites in Mukono district. The team also discussed study logics and revisited our workplans for the project and timelines, prepared study protocols (for sampling storage and shipment) and documents, and submitted applications for IRB approval.

Capacity Building
We established a field study team in Uganda and completed developing study protocols and documents for IRB approval. We selected study sites and developed new workplans and timelines for the project. We obtained study supplies for fecal sample collection, storage, and shipping.

Lessons Learned
The original study design involved 60 children (30 receiving the supplement and 30 in the control group), but Makerere University IRB review team raised several concerns and the sample size was increased to 96 children (48 supplemented and 48 controls).
Due to concerns about food safety and homogeneity, we will source small packages of peanuts from the USA for use in the feeding trials.

Presentations and Publications

Wang, J. August 2019. Development and validation of Methods for Detection of Aflatoxin-Lysine Adduct in Dried Blood Spot Samples. Presentation at USAID Nutrition Innovation Laboratory Annual Meeting, Boston, MA, USA.

Wang, J. June 2019. Modulation of Gut Microbiome and Microbial Metabolome by Food Constituents and Contaminants. Presentation at International Forum on Food Safety, Wuxi, Jiangsu, China.

Wang, J. & Tang, L. May 2019. Regulation of Gut Microbiome and Microbial Metabolome by Peanut Consumption in Uganda Children. Presentation at Annual Meeting of Peanut Innovation Laboratory in Uganda, Kampala, Uganda.

Integrating the power of peanuts into school feeding

PI: Mark John Manary; Washington University in St Louis School of Medicine, St. Louis, MO

Research Locations
University of Ghana, Accra, Ghana; Washington University in St. Louis School of Medicine, St. Louis, MO, USA

Description
School-aged children in Ghana receive largely starchy cereals for their sporadic school meals. A nutritious school meal would likely promote better growth and school performance. This project will develop a cost effective, peanut-based school food for distribution in Ghana and sub-Saharan Africa. Multiple food types, such as pastes, bars and whole peanut options will be considered in developing the final product. The project will then conduct clinical trials in Ghana to determine the effects of product consumption by youth on growth and cognitive learning. The results will help determine whether the power of the peanut, which has been such a game-changer in other food aid products, can be channeled to school-age children as well.

Theory of Change/Impact Pathway(s)
Evidence of positive impacts of consuming peanut-based foods may lead to additional markets and increased demand for locally-sourced peanuts.

Collaborators
Matilda Steiner-Asiedu; University of Ghana, Accra, Ghana

Achievements
Food formulation work began with a LP Tool being created and in the process of being updated with information. Washington University has started the process of subcontracting with University of Ghana and anticipates completion prior to the end of October 2019.

While attending the Ghana Groundnut Working Group meeting and Peanut Innovation Lab Ghana Projects Launching Workshop in Ghana, the PI visited with the University of Ghana collaborator.

Capacity Building
None to date.

Lessons Learned
Given the delays in signing contracts, the work was slow to start; however, efforts will increase in the coming months in an effort to make up the time loss.

Presentations and Publications
None to date.

Gender and Youth Projects Reports

Retaining the next generation of Senegalese farmers

PI: Bradford Mills, Virginia Tech, Blacksburg, VA

Research Locations
Virginia Tech, Blacksburg, VA, USA; University of Georgia, Athens, GA, USA; University of Thies, Thies, Senegal

Description
This project explores climatic and land-tenure constraints to youth participation in the Senegalese groundnut sector. Despite the strong historic emphasis on groundnut production in central and western Senegal, the sector has been stagnant in recent years as climatic variability

and uncertainty in policies have generated a risky production environment. This production environment has also reduced incentives for young adults to enter into groundnut production, leading to high levels of rural out-migration, and threatening the long-run viability of peanut production.

Secondary household survey data, historic climate data, and a primary survey of 1,125 households in the groundnut basin will be used to quantify the economic costs of highly variable production environments and uncertain land-tenure arrangements for young groundnut farmers. The results of these analyses, in conjunction with workshops held with local community groups and farmer organizations, will be used to evaluate the feasibility of technology and policy options to address constraints.

Theory of Change/Impact Pathway(s)

Youth participation is a key to the future viability of the Senegalese groundnut sector. Young people will choose to enter (or remain in) groundnut farming if the sector contributes to a viable livelihood strategy. This project will provide insights regarding the best technical and policy options for reducing production and land tenure risks which, if adopted by development actors, will improve the viability of groundnut production as a household livelihood strategy for the next generation of Senegalese farmers.

Collaborators

Genti Kostandini, University of Georgia, Griffin, GA; Pierre Maurice Diatta, Consultant, Senegal

Achievements

Project activities commenced in the summer of 2019. The project PI traveled to Senegal this summer to establish project collaborations and generate an implementation plan with project partners from the Ecole Nationale Superieure d'Agriculture de Thies (ENSA) and the Senegalese Institute for Agricultural Research (ISRA). Relevant secondary datasets were selected and accessed: climate data for Senegal (NDVI, rainfall, temperature) was downloaded and, following an assessment of available household survey data on agricultural livelihoods, project collaborators decided to focus on the 2011 Enquete de suivi de la pauvrete au Senegal (ESPS) and Demographic and Health Survey rounds for 2011 – 2017. The PIs also drafted a survey instrument for a primary household survey of 1,125 households in the provinces of Kaolack, Kaffrine and Tambacounda. The survey is currently under review by the Virginia Tech Institutional Review Board.

Capacity Building

The team presented a seminar at ENSA on the project objectives and the specific survey models and questions to be asked in the household survey. Approximately 12 researchers (10 men and 2 women) from ENSA and ISRA attended the seminar.

The Virginia Tech and ENSA PIs have drafted and circulated an announcement for two ENSA MS student training opportunities funded by the project and one Virginia Tech MS student opportunity. Applications for these positions are currently being received. An MS student from Senegal will enroll at Virginia Tech in fall 2020. The UGA co-PI has also identified and enrolled a graduate student (USA citizen) research assistant to work on analysis of the secondary datasets.

Lessons Learned
A preliminary analysis of data quality in the 2018 Senegalese Enquête de Recertification du Registre National Unique was conducted, specifically with respect to questions on groundnut production. The analysis found that the dataset contains unrealistic estimates of both groundnut field size and groundnut production and is therefore ill-suited for a study of this type.

Presentations and Publications
None to date.

Farmer Incentives for quality Ghanaian peanuts

PI: Nicholas Magnan, University of Georgia, Athens, GA

Research Locations
UDS, Tamale, Ghana; Project Peanut Butter, Kumasi, Ghana; AMSIG, Tamale, Ghana; University of Georgia, Athens, GA, USA

Description
Groundnut value chains in Ghana are long and fragmented, consisting of many smallholder producers and intermediate traders. In this market environment, the farmer may not receive incentives to grow high quality and safe food, and the produce available at the market is generally low quality and at risk of aflatoxin contamination. Consequently, demand for aflatoxin safe groundnuts is mostly fulfilled by imports even though Ghana is the tenth largest groundnut producing country in the world. Efforts to link smallholder groundnut farmers to high value markets in Ghana rely on an aggregator model, wherein aggregators provide services or inputs to farmers at the beginning of a season, and subsequently purchase their production to sell to downstream buyers. This model has potential but, for a number of reasons, aggregators are challenged in their ability to accumulate safe, adequate groundnut supplies.

This project aims to strengthen value chain linkages by helping aggregators provide yield-enhancing and aflatoxin-reducing inputs to farmers. The impact of offering these input packages will be evaluated using a randomized control trial at the village level. Outcomes of interest include uptake of inputs on credit, quantity of groundnuts sold to the aggregator, quantity of groundnuts kept for home consumption, and groundnut aflatoxin levels. The project will include analysis of gender-specific differences in all outcomes and what may have caused those differences.

Theory of Change/Impact Pathway(s)
By gauging how farmers accept inputs on credit, how much they sell to the aggregator, how much they keep for home consumption, and groundnut aflatoxin levels, the study will serve as a proof of concept to downstream premium buyers, NGOs, or government agencies seeking to enhance smallholders' participation in premium value chains. The study will also provide insights about ways to improve gender inclusivity in groundnut market and value chain interventions.

Collaborators
Vivian Hoffmann, International Food Policy Research Institute (IFPRI), Nairobi, Kenya; Ellen McCullough, University of Georgia, Athens GA; Nelson Opoku, University for Development Studies (UDS), Tamale, Ghana

Achievements
The team brought together resources from agricultural aggregator AMSIG and Project Peanut Butter to try a 10-15 ton sale following the 2019 season. For this sale, the project is supporting AMSIG's aggregation efforts through the provision of tarps, training, and monitoring.

Capacity Building
None to date.

Lessons Learned
It is extremely hard to purchase high quality low aflatoxin groundnuts in meaningful quantities in Ghana. Project Peanut Butter is under new local management and does not want to import nuts from the US anymore. Thus, they are eager to try new things to procure locally through aggregators.

Presentations and Publications
Magnan, N. July 2019. Information, Technology, and Market Rewards: Incentivizing Aflatoxin Control in Ghana. Presentation at Ghana Groundnut Working Group, Tamale, Ghana.

Time poverty among women smallholders in Ghana: Implications for gender priorities in the peanut value chain

PI: Leland Glenna, Pennsylvania State University, University Park, PA

Research Locations
CSIR-SARI, Tamale, Ghana; Pennsylvania State University Reading, PA, USA

Description
Groundnut is a labor-intensive crop, with time constraints at critical points in production. Women are the primary producers and processors of groundnut in Ghana, but their engagement and productivity are limited by traditionally gendered roles and responsibilities. This project investigates time poverty (defined as insufficient time to take on new tasks and responsibilities) and its influence on women's participation in the groundnut value chain. The project will survey men and women's time use at various stages of the production cycle to expand the understanding of time poverty in relation to the groundnut sector. After conducting an inventory of locally-available time-saving and time-enhancing technologies, these technologies will be disseminated through gender-integrated farmer field schools and evaluated for their capacity to enhance women's participation in groundnut production.

Theory of Change/Impact Pathway(s)
A better understanding of the differences between men and women's roles in groundnut production is necessary for the development of appropriate interventions. The study will inform efforts to improve technology adoption amongst smallholder groundnut farmers and assist practitioners in selecting interventions that reduce women's time poverty and enhance women's ability to engage in peanut production.

Collaborators
Edward Martey, CSIR-Savanna Agricultural Research Institute, Nyankpala, Ghana; Doris Kavenaa Puozaa, CSIR-Savanna Agricultural Research Institute, Nyankpala, Ghana; Paige Castellanos, Pennsylvania State University, University Park, PA; Richard Oteng-Frimpong,

CSIR-Savanna Agricultural Research Institute, Nyankpala, Ghana; Janelle B. Larson, Penn State Berks, Reading, PA; Leif Jensen, Pennsylvania State University, University Park, PA

Achievements

During July of 2019, PI Glenna traveled to Ghana to meet with project collaborators and to select and visit the research sites. PI Glenna and co-PI Martey also developed a plan for survey implementation, and the IRB process at Penn State was completed during the reporting period.

Capacity Building

Approval is currently being sought for a Ghanaian graduate student to come to the US to begin a Ph.D. program in Rural Sociology at Penn State.

Lessons Learned

Because smallholder farmers in the study area usually do not wear watches, it would be difficult for them to self-report their daily activities in 15-minute intervals. As a result, the time use survey will record activities in 30-minute intervals.

Presentations and Publications

Glenna, L. L., Martey, E., Castellanos, P., Larson, J., Puozaa, D. K., Jenson, L., & Oteng-Frimpong, R. July 2019. Time Poverty Among Women Smallholders in Ghana: Implications for Gender Priorities in the Peanut Value Chain. Presentation at Peanut Innovation Lab Meeting in Tamale, Ghana, Tamale, Ghana.

Photovoice for Ugandan youth empowerment

PI: Carrie Ann Stephens, University of Tennessee, Knoxville, TN

Research Locations

Makerere University, Kampala, Uganda; NARO-NaSARRI, Soroti, Uganda; University of Tennessee, Knoxville, TN, USA

Description

Youth participation in farming is critical for the future of Ugandan groundnut production, yet avenues for fostering youth engagement remain unclear. This project uses photovoice – a participatory visual research methodology – to compare the experiences of young men and women living in rural, groundnut-producing communities of Northern and Eastern Uganda, and to investigate the factors that empower and enable youth to be active stakeholders in the groundnut value chain. The study will also evaluate the use of photovoice itself as a tool for empowerment. Thirty youth will be trained in photovoice and will subsequently collect photos using smartphones over the course of two groundnut production seasons, select photos, explain their photo-stories, and then participate in focus group discussions to further articulate their actual and ideal engagement in groundnut value chains. The findings will be disseminated through community festivals, oral presentations, written reports, workshops, and a digital platform to host a repository of visuals of youth empowerment in peanut value chains.

Theory of Change/Impact Pathway(s)

The results of this study will help practitioners to design agricultural policies and interventions that reflect youth aspirations and reduce the barriers to their engagement in Ugandan groundnut production. The project will also produce best practices for using photovoice as a method for

understanding and empowering rural, Ugandan youth, which can be adopted by practitioners in their own future work.

Collaborators
Archileo Kaaya, May Sengendo and Stephen Lwasa, Makerere University, Uganda; David Okello, NARO-NaSARRI, Uganda; Tom Gill and Jennifer Richards, University of Tennessee, Knoxville, TN

Achievements
University of Tennessee faculty and an MS student, along with David Okello, and Makerere University and MS students in Uganda have developed a partnership around youth empowerment in the peanut value chain. We have collaborated with two districts in Uganda (Tororo and Nwoya) and their agricultural support groups to start this project.

Capacity Building
One female (US) MS student was enrolled at the University of Tennessee and two male (Ugandan) MS students were enrolled at Makerere University. In August 2019, University of Tennessee faculty trained the Ugandan co-PIs and MS students (one woman and five men) on the photovoice and participatory mapping methodologies that will be used in the project.

Lessons Learned
None to date.

Presentations and Publications
None to date.

Gender dynamics in Senegalese peanut production

PI: Stuart Sweeney, University of California, Santa Barbara, CA

Research Locations
University of California, Santa Barbara, CA, USA; Université de Gaston Berger, Saint-Louis, Senegal

Description
Achieving gender equality in agricultural development is fundamental to reduce global poverty, hunger and malnutrition. Women's participation in Senegalese groundnut farming is embedded in social context and linked to the work and needs of others in the household and community. Although women play a critical role in groundnut production, their efforts may be impacted by inefficient and inequitable allocations of labor and resources with respect to complex household structures and concomitant intra- and inter-household gendered power dynamics. Existing research is lacking in terms of providing an adequate description of these interconnections, as well as the ways in which they mediate the impacts of stressful events.

This project researches how men and women's engagement in various aspects of groundnut production in Senegal is influenced by intra-household structure and gendered power dynamics, and how those relationships are further impacted by stressors including 1) the initiation, timing, and spacing of births; and 2) concurrent climate shocks (precipitation and temperature). Traditional time-use study methods have significant limitations in low-literacy, low-resource populations like those of rural farmers in Senegal. The project is developing an innovative method for measuring time use employing wrist-worn technologies (activity monitors and

recorders) to periodically signal participants to record audio clips of their activities. This method has several potential advantages over traditional approaches including minimized participant burden, increased granularity, decreased seasonality effects, more specific coding and analysis, and less required resources.

Theory of Change/Impact Pathway(s)

A better understanding of the differences between men and women's roles in groundnut production is necessary for the development of appropriate interventions. The research takes a complex systems approach to understanding the lives and livelihoods of male and female groundnut farmers. The results will inform the development of multi-sectoral strategies (involving e.g. agriculture, health, environment and education) to improve the resilience and gender inclusivity of groundnut production in rural Senegal. While time-saving technologies have been proposed as a solution to time poverty in this region, they may be ineffectual if implemented without an understanding of the power dynamics that keep women working in limited roles and for many hours. Analyses of farmer responses to weather shocks can be used to understand resilience, and model production outcomes under future climate scenarios. Monitoring time use during both the dry and rainy season will provide a more detailed understanding of how men and women's time-use varies at different times of the year, which practitioners can use to refine the timing of their interventions.

Finally, the innovative wrist-worn technology and associated protocols developed through the project will be of significant benefit to other researchers seeking to understand time use and activities in similar contexts.

Collaborators

Samba Mbaye, Université de Gaston Berger, Saint-Louis, Senegal; Mamadou Ba, Université de Gaston Berger, Saint-Louis, Senegal; Jacqueline Banks, University of Minnesota, Minneapolis, MN; Sari Blakeley, University of California, Santa Barbara, CA

Achievements

Project activities began in summer 2019 and have, to-date, focused primarily on the development of a Santa Barbara-based pilot study to validate the new time-use data collection method and refine engineering modifications made to the activity-tracking device. A study protocol was designed and subsequently approved by UCSB's Human Subjects Committee; it includes consenting documentation, heart rate calibration protocol for the wrist-worn technology, traditional time use diaries, audio wrist-worn technology protocols, demographic questionnaires, stress assessments, and household cooperation surveys. A UCSB undergraduate research assistant was hired to help with the data collection and consenting processes of the pilot study, and a mobile/computer programmer was hired to design and create an application to capture time-use heart rate and activity audio. The team also began assessing suitable devices for audio capture and heart rate monitoring time-use technologies based on durability, battery life, programmability, and cultural acceptance.

Capacity Building

Two female Senegalese graduate students were identified and brought on to the project.

Lessons Learned

Many of the devices available on the market have difficulty measuring heart-rate on users with dark skin.

Presentations and Publications

Arabadjis, S., Banks, J., Schlund, S., Blakeley, S., & Sweeney, S. 2019. New Methods in Time Use: Wrist-worn Technology.

Associate Award Research Project Reports

No associate awards were active for FY19.

Human and Institutional Capacity Development

Short-term Training (Individual)

Name	Gender	Home Country	Home Institution	Dates	Discipline	Research Focus	Training Location
Abdi Hassan	M	Ethiopia		6/27-7/11/19	Attend APRES Meeting		Auburn, AL

Short-term Training (Workshops/Courses)

Name/Type of Event	Male	Female	Dates	Trainer/Institution	Research Focus	Training Location
Digital data management system for breeding	6	2	10/23/18	David Okello	Training on BMS functionalities and E-data capture	Royal Suites Bugolobi, Uganda
Senegal planning meeting	16	6	11/16/18	Peanut IL ME	Meeting to discuss Senegal projects.	Senegal
Digital data management system for breeding	8	3	12/4/18	David Okello	Training on BMS functionalities and E-data capture	DARS, Lilongwe-Malawi
Digital data management system for breeding	4	0	12/7/18	David Okello	Training on BMS functionalities and E-data capture	ZARI, Chipata-Zambia
Digital data management system for breeding	5	3	12/10/18	David Okello	Training on BMS functionalities and E-data capture	IIAM, Nampula, Mozambique
Seed production and breeding needs assessment	8	4	3/11/19	David Okello		Nkopola, Mangochi
Digital data management system for breeding	8	4	3/11/19	David Okello	Training on BMS functionalities and E-data capture	DARS, Lilongwe-Malawi
Seed production and breeding needs assessment	8	7	3/12/19	David Okello	Trainings of farmers in Quality Seed Production	Mthilakubili - Ludazi, Zambia
Digital data management system for breeding	13	4	3/13/19	David Okello	Training on BMS functionalities and E-data capture	ZARI HQ, Lusaka-Zambia
Seed production and breeding needs assessment	7	8	3/14/19	David Okello	Trainings of farmers in Quality Seed Production	Katopola FTC-Chipata, Zambia

Name/Type of Event	Male	Female	Dates	Trainer/Institution	Research Focus	Training Location
Digital data management system for breeding	3	2	3/15/19	David Okello	Training on BMS functionalities and E-data capture	IIAM, Nampula, Mozambique
Seed production and breeding needs assessment	33	39	3/18/19	David Okello	Trainings of farmers in Quality Seed Production	Uganda Cooperative Alliance College Tororo, Uganda
Digital data management system for breeding	6	4	3/20/19	David Okello	Training on BMS functionalities and E-data capture	Akello Hotel Soroti, Uganda
Shrub propagation techniques and optimized shrub system management	15	8	3/21/19	ENSA PI Team	The objective was to strengthen the capacity of farmers of the village of Diam Wheli who are part of the network of farmers working with the NGO Symbiose based at Nioro, on *Piliostigma reticulatum* propagation.	ENSA, Senegal
Seed production and breeding needs assessment	17	13	4/1/19	David Okello	Trainings of farmers in Quality Seed Production	Ngetta ZARDI, Lira
Digital data management system for breeding	13	7	4/1/19	David Okello	Training on BMS functionalities and E-data capture	NaSARRI Serere, Uganda
Shrub propagation techniques and optimized shrub system management	14	6	5/21/19	ENSA PI Team	The objective was to strengthen the capacity of farmers and leaders of Union des Groupements de Producteurs de Meckhe (UGPM) on shrub propagation and optimized shrub system management.	ENSA, Senegal

Name/Type of Event	Male	Female	Dates	Trainer/Institution	Research Focus	Training Location
Onsite Training for Study Protocols	4	2	5/27/19	Jia-Shen Wang, UGA	Get familiar with the study design and study protocols as well as selection of study sites	Kampala, Uganda
Uganda Projects Launch Workshop	24	14	5/28/19	Peanut IL ME	The purpose of this training is to share information about projects across all areas of inquiry.	Uganda
SNP genotyping data analysis workshop	17	3	6/17/19	Peggy Ozias-Akins	To analyze genotyping data from African breeding materials	ISRA-CERAAS
American Peanut Research and Education Society meeting	2		7/7-7/11/19	Peanut IL ME	Annual gathering of peanut researchers	Auburn University
Ghana Groundnut Working Group	37	9	7/23/19	Peanut IL ME	Bring together the leaders in Ghanaian groundnut production and marketing across the value chain for an inaugural meeting of what may become an annual symposium.	Tamale, Ghana
Ghana Project Launch Workshop	38	10	7/24/19	Peanut IL ME	Bring together PIs, co-PIs, collaborators and students from across the areas of inquiry to introduce and hone projects in Ghana	Tamale, Ghana
Shrub Plantation - Piliostigma	17	0	7/30/19	ENSA PI Team	The objective was to strengthen the capacity of farmers of the village of Diam Wheli on *Piliostigma reticulatum* seedlings plantation.	ENSA, Senegal

Name/Type of Event	Male	Female	Dates	Trainer/Institution	Research Focus	Training Location
Shrub Plantation	11	4	9/14/19	ENSA PI Team	The objective was to strengthen the capacity of farmers of UGPM on *Guiera senegalensis* seedlings plantation.	ENSA, Senegal
Photovoice and Participatory Mapping Training	4	3	9/23/19	University of Tennessee Faculty	This training was provided to Makerere faculty and MS students in the technologies of Photovoice and Participatory Mapping.	Kampala, Uganda

Long-term Training

Name	Gender	Home Country	Degree	Graduation Date	Discipline	Mentor(s)	Training Institution
Ahmed Seidu	M	Ghana	PhD	7/31/22	Agronomy and Pest Management	David Jordan	SARI/UDS
Danielle Essandoh	F	Ghana	MSc	9/5/20	Plant Breeding & Genetics	Soraya Bertioli, David Bertioli, Naveen Puppala	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University
Emmanuel Sie	M	Ghana	MPhil	6/30/20	Plant Breeding	Maria Balota	University of Ghana
Leslie Commey	M	Ghana	PhD	8/31/21	Plant and Soil Science	Venugopal Mendu	Texas Tech University
Stephen Arthur	M	Ghana	PhD	8/30/22	Agronomy & Pest Management	David Jordan	KNUST
Tabitha Lomotey	F	Ghana	MSc	9/5/20	Plant Breeding & Genetics	Naveen Puppala	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University
Davis Gimode	M	Kenya	PhD	5/19/19	Plant Breeding, Genetics & Genomics	Peggy Ozias-Akins	University of Georgia, Tifton, GA USA

Name	Gender	Home Country	Degree	Graduation Date	Discipline	Mentor(s)	Training Institution
Rachel Chemutai	F	Kenya	MSc	9/5/20	Plant Breeding & Genetics	Naveen Puppala	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University
Velma Okaron	F	Kenya	PhD	9/4/21	Plant Breeding & Genetics	Soraya Bertioli, David Bertioli, Naveen Puppala	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University
Aminou Maman Mouta	M	Niger	PhD	3/31/22	Agrophysiology	Venugopal Mendu	ICRISAT
Mariama Heynikoye	F	Niger	PhD	4/1/21	Agronomy	Venugopal Mendu	ICRISAT
Codou Ndiaye	F	Senegal	PhD	6/1/21		Stuart Sweeney	University Gaston Berger
Hamady Ba	M	Senegal	MS	7/30/21	Agronomy with Rural Economics specialization	Mark Erbaugh	University of Thies, National Superior School of Agriculture (ENSA)
Joseph Gomis	M	Senegal	PhD	5/31/22	Molecular Genetic	Not yet defined	ISRA-CERAAS
Maimouna Diop	F	Senegal	MA	6/1/20		Stuart Sweeney	
Mamadou Ba	M	Senegal	MS	7/30/21	Agronomy with Rural Economics specialization	Mark Erbaugh	University of Thies, National Superior School of Agriculture (ENSA)
Moussa Diedhiou	M	Senegal	PhD	6/1/23	Agronomic Sciences	Richard Dick	University of Thies, National Superior School of Agriculture (ENSA)
Daisy Kemigisha	F	Uganda	MSc	8/19/21	MSc Agric Economics	Carrie Stephens	Makerere University
Esther Achola	F	Uganda	PhD	5/31/22	Plant Breeding & Genetics	Peggy Ozias , Mike Deom, Josh Clevenger, Naveen Puppala	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University

Name	Gender	Home Country	Degree	Graduation Date	Discipline	Mentor(s)	Training Institution
Henry Winkler	M	Uganda	MS	9/5/20	Crop Science (crop protection)	Mike Deom, Severin Paul	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University
Ivan Chapu	M	Uganda	MS	9/4/20	Plant Physiology	Maria, Balota, Naveen Puppala	Makerere Regional Center for Crop Improvement (MaRCCI), Makerere University
Martha Mirembe	F	Uganda	MSc	8/19/21	Msc. Food Science and Technology	Carrie Stephens	Makerere University
Anna Veazey	F	United States	MS	5/10/21	Agricultural Leadership, Education and Communications	Carrie Stephens	University of Tennessee
James Davis	M	United States	PhD	9/6/21	Agricultural and Applied Economics	Genti Kostandini	The University of Georgia
Sean Posey	M	United States	PhD	5/14/22	Agricultural and Applied Economics	Nicholas Magnan	University of Georgia
Sophia Arabadjis	F	United States	MS	5/31/23	Geography	Stuart Sweeney	University of California at Santa Barbara

Environmental Management and Mitigation Plan (EMMP)

All project PIs and partners are briefed on the Peanut Innovation Lab EMMP. The Director and Assistant Director monitor compliance with the EMMP during their frequent visits to in-country research sites.

As most projects that involve field research that would fall under the EMMP, no issues have been identified during FY19.

Open Data Management Plan

All PIs and project partners are briefed on the Peanut Innovation Lab Data Management Plan. The Director and Assistant Director monitor compliance with the plan and work with each project to identify data sets that will arise from project research. These are entered into the

Piestar DPx system to follow progress towards submission to the appropriate repository. All projects must complete the DPx Data Management module as part of the semi-annual and annual reporting process.

The following data sets have been submitted during FY19.

Data set	Repository	Responsible Person
SNP genotypes for African peanut lines	PeanutBase	Peggy Ozias-Akins, UGA

Governance and Management Entity Activity

Governance and management entity activities are described above in the Program Activities and Highlights section.

Other Topics

None to report.

Issues

None to report.

Future Directions

The Peanut Innovation Lab is supporting research partnerships between US and local institutes in each of four Areas of Inquiry: variety development, value-added gains, nutrition and gender & youth. The following provides an overview of the research activities planned for FY20.

Ghana

Variety Development: The two active groundnut breeding programs in Ghana hosted by the CSIR-Crop Research Institute (CRI, James Asibuo) and Savanna Agriculture Research Institute (SARI, Richard Frimpong) are actively involved in several projects coordinated across all Peanut Innovation Lab breeding projects, including a continent-wide initiative linking National Agricultural Research Systems (NARSs) to evaluate and use peanut genetic diversity, test low-cost high-throughput phenotyping technologies (with Maria Balota, Virginia Tech), integrate advanced informatic and digital tools for data capture and analysis, employ marker-assisted selection, and improve breeding program efficiencies. The projects are building on long-term relationships established with US scientists who have collaborated successfully for many years and resulted in several improved varieties, including the first high oleic peanut variety in Africa (improved fat quality for nutrition and shelf life) bred at Texas Tech University by SARI

scientist Nicholas Denwar with support from Mark Burow at Texas A&M University. Partners will continue to increase seed of improved varieties through the value-added gains projects, improving seed markets and quality.

Value-Added Gains: Two projects anchor this area and are highly integrated with the other three areas. Building on many years of collaboration, North Carolina State University (David Jordan) is working with SARI, CRI and KNUST to evaluate production technologies to define minimal, intermediary and optimal packages, including cost-efficient, integrated Good Agricultural Practices such as row planting, planting density, inoculants, Aflasafe, calcium, weeding and pest/disease management. Effective methods to determine optimal harvest date are also being investigated and disseminated to farmers.

The project will help host a second annual groundnut sector collaboration meeting with the Ghana Groundnut Working Group, created to facilitate communication and collaboration between all market segments and both public and private sector entities.

A second project (University of Georgia/IFPRI, Nick Magnan) will evaluate the emerging high value market for low aflatoxin peanuts through aggregator contracting mechanisms. This project will support the few major aggregators in the USAID Zones of Influence to test offering technologies as part of a contract approach to help smallholders access this market by improving productivity and quality. This will be done as a randomized control trial; technologies to be evaluated include Aflasafe, tarps for drying, and/or inputs to increase productivity. This approach will be the key to generating investment in these areas and builds on experience and partnerships developed under the Peanut and Mycotoxin Innovation Lab with UGA, IFPRI and UDS in Tamale.

Nutrition: Mark Manary (Washington University-St. Louis) and Project Peanut Butter in Kumasi, in partnership with the University of Ghana (Matilda Steiner-Asiedu) will develop a novel peanut-based food product and study of the developed food to enhance the health and cognitive learning capacity of children. Project Peanut Butter will also serve as a market opportunity for the aggregators involved in the above value-added gains projects.

Gender and Youth: While all projects will incorporate gender and youth dimensions, a project led by Leland Glenna at Pennsylvania State and Edward Martey at SARI will conduct qualitative case studies to understand women's time allocation and evaluate a wider suite of technologies, such as hand planters, shellers and tarps. The project will align with Jordan and Magnan as a complementary qualitative approach. Magnan's project's scope was increased to incorporate deeper focus on women's inclusion in commercialization strategies.

Malawi

Variety Development: The national groundnut breeding program is led by Justus Chintu at the Department of Agriculture Research Services (DARS). The program is actively involved in several projects coordinated across the entire Peanut Innovation Lab breeding projects, including a continent-wide initiative linking NARSs on evaluating and using peanut genetic diversity, low-cost high-throughput phenotyping technologies, integrating advanced informatic and digital tools for data capture and analysis, marker-assisted selection, and improving breeding program efficiencies. The projects are building on long-term relationships established with US scientists, including collaboration between Chintu and Naveen Puppala at New Mexico State University. This work is in coordination with the mission-funded Malawi Agriculture Diversification

Activity (AgDiv) and linked with both the tobacco diversification strategy and AATF/Syngenta Seeds2B initiatives. These initiatives are focused on diverse variety trials targeting market types better suited to regional export as well as agronomic performance (yield, grade, disease resistance, drought tolerance) and potentially high oleic acid for improved shelf life.

Value-Added Gains: The project is managed in coordination with the AgDiv project on evaluation of good agricultural practices. The objective is to evaluate a suite of technologies, including inoculant, calcium and other soil fertility inputs, planting date and density, and other inputs as determined by participants. These trials look at both interactions and isolated response across several varieties to determine optimal economic returns in both high and low-input production systems. The Innovation Lab funded aspects include incorporation of graduate student training at LUANAR for improved capacity building with linkages to the private sector and better data collection and analysis. A second activity involves widespread data collection in coordination with several partners, including the tobacco leaf-grower networks to develop remote sensing/satellite capabilities to evaluate peanut production area and yield potential with a long term project at Stanford University.

Senegal

Variety Development: Daniel Fonceka (ISRA-CERAAS) and Issa Faye (ISRA-CNRA) are actively involved in several projects coordinated across Peanut Innovation Lab breeding projects including leading the West African component of a continent-wide initiative linking NARSs to evaluate and use peanut genetic diversity, test low-cost high-throughput phenotyping technologies, integrate advanced informatic and digital tools for data capture and analysis, employ marker-assisted selection, and improve breeding program efficiencies. The projects are building on long-term relationships established with US scientists, including leading genomics researchers at UGA, that have resulted in the release of several improved varieties. Two additional projects involve the use of cutting-edge genomic technology for marker development and introduction of alleles from the wild relatives of peanuts that will improve the genetic diversity of cultivated peanut with the potential to offer new mechanisms for disease resistance, drought tolerance and other traits.

Value-Added Gains: A major focus of the Innovation Lab's work in Senegal is improving the resilience of peanut cropping systems. Richard Dick at Ohio State University, in collaboration with researchers at ENSA, has developed a locally adapted agroforestry system for the peanut/millet system using leguminous indigenous shrub species. Once established, the shrubs can be cut and mulched and have been shown to improve soil fertility, but also to "bio-irrigate" nearby crops during drought period by pulling water from deeper in the water table. The project is optimizing the integration of peanuts into the cropping system and collecting data on efforts to better adapt and scale the technology through farmer managed evaluations in three agroecosystems. They will also be working on a complimentary project with the Legume Systems Innovation Lab to evaluate impacts on cowpea in the system.

Gender and Youth: Two complimentary projects, one on gender and another on youth, will focus on resilience. Stuart Sweeny at University of California-Santa Barbara is leading a project looking at several aspects of women's ability to engage in the peanut cropping system, particularly labor/time poverty and fertility over time and in relation to climate. The project is using voice recorders and individual time tracking devices (similar to the wrist-watch style fitness trackers many people wear) to attempt to overcome limitations of recall data and also an

in-depth survey and qualitative research. Bradford Mills at Virginia Tech is leading a project supporting graduate students at ENSA and collecting survey data targeting the impact of land availability and youth engagement in the Zone of Influence.

Uganda

Variety Development: David Okello (NARO-NaSARRI), national groundnut breeder, leads the East African component of a continent-wide initiative linking NARSs to evaluate and use peanut genetic diversity, test low-cost high-throughput phenotyping technologies (with Maria Balota, Virginia Tech), integrate advanced informatic and digital tools for data capture and analysis, employ marker-assisted selection, and improve breeding program efficiencies. The program will also evaluate new peanut lines that have new diversity derived from wild species developed at the UGA. The Uganda efforts will have a special focus on developing effective technology to breed for groundnut rosette disease resistance. Seed increase of improved varieties will continue and link with the value-added gains projects to improve seed markets and quality. Several MSc and PhD students hosted by MaRCCI will conduct their research with support from the projects.

Value-Added Gains: NARO-NaSARRI and UGA will work together to confirm the alternative host for groundnut rosette virus (GRD). GRD is one of the most destructive diseases of groundnut in Africa, and determining the alternate host is important in developing resilient management strategies to fight the disease. NARO-NaSARRI have identified a potential host and UGA will provide the required molecular analyses.

Nutrition: Makerere University School of Public Health (John Ssempebwa) and University of Georgia College of Public Health (J.S. Wang) are collaborating to determine the effects to the gut microbiome of youth who consume peanut. The study is designed to determine the nutrition impacts of peanuts.

Gender and Youth: While all projects will incorporate gender and youth dimensions, a project between Makerere University College of Agriculture and Environmental Sciences and University of Tennessee (Carrie Stephens) will use photovoice to determine if this approach can increase youth interest in agriculture, especially groundnut. The method has been used in nutrition and health studies in Uganda and involves using photos to document and discuss priorities in the value chain.

Appendix A. List of Awards to Partners

A1. US Partners (by State)

Institution	Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY 2019 Budget	Total Budget
California				$83,392	$431,758
Stanford University	Examining the Utility of Satellite-based Assessment in a Maize/Peanut Agroecosystem for Estimated Crop Response in Malawi *(sub-award from NCSU)*	10/1/2018	9/30/2021	$22,000	$65,000
University of California, Santa Barbara (UCSB)	Gender, Fertility, and Intra-household Dynamics and resilience in the Senegalese Peanut Farmers in Ghana	7/1/2019	12/31/2021	61,392	$366,758
District of Columbia				$25,860	$122,051
International Food Policy Research Institute (IFPRI)	Connecting Male and Female Smallholder Farmers to Premium Groundnut Markets and Aflatoxin-mitigating Technologies through Innovation Aggregator Contracts *(sub-award from UGA)*	8/1/2018	7/31/2022	$25,860	$122,051
Florida				$5,040	$15,120
University of Florida (UFL)	Development and Delivery of Improved Production and Pest Management Packages to Peanut Farmers in Ghana *(sub-award from NCSU)*	10/1/2018	9/30/2022	$5,040	$15,120
Georgia				$457,213	$2,238,466
University of Georgia (UGA)	Leveraging Genetics Resources to Enhance Peanut/Groundnut Breeding in Africa and the United States	10/1/2018	9/30/2022	$21,700	$21,700
	Use if Novel Genetic Diversity for Peanut Varietal Development in East Africa	9/1/2018	9/1/2021	$37,441	$110,000
	Incorporating New Wild Alleles to Improve Elite African Peanut Cultivars	10/1/2018	9/30/2021	$30,220	$110,000
	Mapping Groundnut Rosette Virus (GRV) Resistance to Marker-assisted Selection	10/1/2018	9/30/2021	$19,250	$67,610
	Connecting Male and Female Smallholder Farmers to Premium Groundnut Markets and Aflatoxin-Mitigating Technologies through innovation Aggregator Contracts	8/1/2018	7/31/2022	$62,175	$215,331
	Identifying the Alternative Host for Groundnut Rosette Disease Virus Complex	8/1/2018	2/1/2021	$22,600	$47,800
	Regulation of Gut Microbiome by Peanut Supplement in Youth with both Genders	4/1/2019	9/30/2022	$118,205	$453,555
	Enhancing the Genetics Potential of Peanut Production in Eastern/Southern Africa *(sub-award from NASARRI)*	2/1/2019	7/31/2022	$7,700	$15,400
	Enhancing the Genetics Potential of Peanut Production in West Africa *(sub-award from ISRA)*	2/1/2019	7/31/202	$7,700	$15,400

Institution	Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY 2019 Budget	Total Budget
	Genotypic Analysis of Peanut using Axiom_Arachis2 SNP Array	5/1/2018	4/30/2019	$106,670	$106,670
	Retaining Next Generation Farmers in the Senegalese Groundnut Basin *(sub-award from Virgina Tech)*	3/1/2019	2/28/2022	$23,552	$75,000
Missouri				$88,480	$341,279
Washington University at St. Louis (WUSTL)	Integrating the Power of Peanuts into School Feeding	1/1/2019	9/30/2022	$88,480	$341,279
North Carolina				$78,226	$330,140
North Carolina State University (NCSU)	Examining the Utility of Satellite-based Assessment in a Maize/Peanut Agroecosystem for Estimated Crop response in Malawi	10/1/2018	9/30/2021	$32,393	$86,604
	Development of Efficient Agronomic Peanut Production Packages for Malawian Farmers	10/1/2019	7/31/2022	$0	$113,811
	Development and Delivery of Improved Production and Pest Management Packages to Peanut Farmers in Ghana	10/1/2018	9/30/2022	$45,833	$129,725
Ohio				$66,013	$186,433
Ohio State University (OSU)	Optimized Shrub System (OSS): an Innovation for Landscape Regeneration and Improved Resilience for the Peanut-Basin on Senegal	9/1/2018	8/31/2022	$66,013	$186,433
Pennsylvania				$100,957	$371,329
Pennsylvania State University (Penn State)	Time Poverty among Women Smallholder in Ghana: implications for Gender Priorities in the Peanut Value Chain	3/1/2019	10/31/2022	$100,957	$371,329
Tennessee				$67,876	$180,414
University of Tennessee (UT)	Photovoice for Youth Empowerment in Peanut Value Chain	3/1/2019	2/28/2022	$67,876	$180,414
Texas				$111,207	$265,587
A&M University (Texas A&M)	Breeding and Enhancement of Tolerance to Water Deficit, Resistance to leaf Spot and Improved Oil Composition on Peanut	10/1/2018	9/30/2022	$18,488	$86,431
Texas Tech University (TTU)	Developing Aspergillus flavus Resistance Peanut using Seed Coat biochemical marker(s)	10/1/2018	9/30/2022	$92,719	$179,159
Virginia				$79,788	$268,800
Virginia Polytechnic Institute and State University (VT)	Integration of High Throughput Phenotyping (HTP) for Enhancing Breeding Programs in Senegal, Ghana, Uganda, and Regional Cooperation	9/1/2018	11/302022	$38,400	$73,680
	Development and Delivery of improved Production and Pest Management Packages to Peanut Farmers in Ghana *(sub-award from NCSU)*	10/1/2018	9/30/2022	$5,040	$15,120
	Retaining Next Generation Farmers in the Senegalese Groundnut Basin	3/1/2019	2/28/2022	$36,348	$180,000

A2. Non-US Partners (by Country)

Institution	Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2019 Budget	Total Budget
Ghana				$170,018	$687,032
CSIR-Crop Research Institute (CRI)	Development and Delivery of Improved Production and Pest Management Packages to Peanut Farmers in Ghana *(sub-award from NCSU)*	10/1/2018	9/30/2022	$21,450	$82,940
Kwame Nkrumah University of Science and Technology (KNUST)	Development and Delivery of Improved Production and Pest Management Packages to Peanut Farmers in Ghana *(sub-award from NCSU)*	10/1/2018	9/30/2022	$25,396	$87,833
Project Peanut Butter	Integrating the Power of Peanuts into School Feeding	1/1/2019	9/30/2022	$0	$123,232
CSIR-Savanna Agriculture Research Institute (SARI)	Integration of High Throughput Phenotyping (HTP) for Enhancing Breeding Programs in Senegal, Ghana, Uganda and Regional Cooperation *(sub-award from VT)*	9/1/2018	11/30/2022	$34,893	$66,557
	Breeding and Enhancement of Tolerance to Water Deficit, Resistance to Leaf spot and Improved Oil Composition on Peanut *(sub-award from Texas A&M)*	10/1/2018	9/30/2022	$5,830	$37,170
	Development and Delivery of Improved Production and Pest Management Packages to Peanut Farmers in Ghana *(sub-award from NCSU)*	10/1/2018	9/30/2022	$36,190	$168,850
	Time Poverty among women Smallholders in Ghana: Implications for Gender Priorities in the Peanut Value Chain *(sub-award from Penn State)*	3/1/2019	10/31/2022	$22,259	$65,630
	Breeder Seed Production and Assessment of Breeding Programs Capacity building in targeted African Countries *(sub-award from NARO-NASARRI)*	5/1/2018	4/30/201	$24,000	$24,000
	Enhancing the Genetic Potential on Peanut Production in West Africa (*sub-award from ISRA*)	2/1/2019	7/31/2022	$0	$30,800
University for Development Studies (UDS)	Connecting male and female smallholder farmers to premium groundnut markets and aflatoxin-mitigating technologies through innovation aggregator contracts *(sub-award from UGA)*	8/1/2018	7/31/2022	$97,292	$263,210
University of Ghana	Integrating the Power of Peanuts into School Feeding *(sub-award from WU)*	1/1/2019	9/30/2022	$9,331	$35,221
India				$5,520	$25,000
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Developing Aspergillus flavus resistant Peanut using Seed Coat biochemical marker(s) *(sub-award from TTU)*	10/1/2018	9/30/2021	$5,520	$25,000
Kenya				$49,500	$174,900

Institution	Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2019 Budget	Total Budget
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Mapping Groundnut Rosette Virus (GRV) resistance for marker-assisted selection *(sub-award from UGA)*	10/1/2018	9/30/2021	$49,500	$174,900
Malawi				$19,700	$241,705
DARS-Chitedze Agriculture Research Service	Development of Efficient Agronomic Peanut Production Packages for Malawian Farmers *(sub-award from NCSU)*	2/1/2019	7/31/2022	$0	$26,400
	Enhancing the Genetic Potential of Peanut Production in Eastern/Southern Africa *(sub-award from NARO/NaSARRI)*	2/1/2019	7/31/2022	$0	$34,100
	Breeder Seed Production and Assessment of Breeding Programs Capacity building in targeted African Countries *(sub-award of NARO/NaSARRI)*	5/1/2018	4/30/2019	$12,000	$12,000
Horizon Farms, Ltd.	Examining the Utility of Satellite-based Assessment in a Maize/Peanut Agroecosystem for Estimated Crop response in Malawi *(sub-award from NCSU)*	10/1/2018	9/30/2021	$7,700	$24,430
	Development of Efficient Agronomic Peanut Production Packages for Malawian Farmers *(sub-award from NCSU)*	10/1/2019	7/31/2022	$0	$51.150
Lilongwe University of Agriculture and Natural Resources (LUANAR)	Development of Efficient Agronomic Peanut Production Packages for Malawian Farmers *(sub-award from NCSU)*	10/1/2019	7/31/2022	$0	$93,625
Mali				$0	$30,800
Institut d'Economie Rurale (IER)	Enhancing the Genetic Potential of Peanut Production in West Africa *(sub-award from ISRA)*	2/1/2019	7/31/2022	$0	$30,800
Mozambique				$12,000	$56,100
Instituto de Investigação Agrária de Moçambique (IIAM)	Enhancing the Genetic Potential of Peanut Production in Eastern/Southern Africa *(sub-award from NARO/NaSARRI)*	2/1/2019	7/31/2022	$0	$34,100
	Breeder Seed Production and Assessment of Breeding Programs capacity building in targeted African Countries *(sub-award from NARO/NaSARRI)*	5/1/2018	4/30/2019	$12,000	$12,000
Niger				$44,840	$126,650
International Crops Research Institute for the Semi-Arid Tropics (ICRISAT)	Developing Aspergillus-flavus resistant Peanut using seed coat biochemical marker(s) *(sub-award from TTU)*	10/1/2018	9/31/2021	44,840	$95,850
Centre Regional de la Recherche Agronomique du Niger (INRA)	Enhancing the Genetic Potential of Peanut Productions in West Africa *(sub-award from ISRA)*	2/1/2019	7/31/2022	$0	$30,800
Senegal				$210,238	$783,601

Institution	Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2019 Budget	Total Budget
Centre de Recherche Pour le Developpement Economique et Social Sanar (CRDESS)	Gender, Fertility, and Intra-household dynamics and resilience in the Senegalese Peanut Production Chain *(sub-award from UCSB)*	7/1/2019	12/31/2021	$0	$84,840
Ecole Nationale Superieure d'Agriculture de Thies (ENSA)	Retaining Next Generation Farmers in the Senegalese Groundnut Basin *(sub-award from VT)*	3/1/2019	2/28/2022	$3,132	$95,000
Institut Senegalais de Recherches Agricoles (ISRA)	Integration of High Throughput Phenotyping (HTP) for enhancing Breeding Programs in Senegal, Ghana, Uganda and regional Cooperation *(sub-award from VT)*	9/1/2018	11/30/2022	$33,243	$67,107
	Breeding and Enhancement of Tolerance to water deficit, resistance to leaf spot and improved oil composition on Peanut *(sub-award from Texas A&M)*	10/1/2018	9/30/2022	$3,850	$26,400
	Enhancing the Genetic Potential of Peanut Production in West Africa	2/1/2019	7/31/2022	$33,000	$191,400
	Breeder Seed Production and Assessment of Breeding programs capacity building in targeted African Countries *(sub-award from NARO/NaSARRI)*	5/1/2018	4/30/2019	$12,000	$12,000
	Genotypic analysis of Peanut Germplasm using Axiom-Arachis2 SNP array *(sub-award from UGA)*	5/1/2018	4/30/2019	$53,350	$53,350
	Incorporating new wild alleles to improve elite West African Peanut Cultivars *(sub-award from UGA)*	10/1/2018	9/30/2021	$30,050	$90,000
University of Thies	Optimized Shrub System (OSS): an Innovation for Landscape Regeneration and Improved Resilience for the Peanut-basin of Senegal (*sub-award from OSU*)	9/1/2018	8/31/2022	$41,613	$163,504
Uganda				$410,860	$838,842
Makerere University	Photovoice for Youth Empowerment in Peanut Value chains in Uganda *(sub-award from UT)*	3/1/2019	2/28/2022	$23,441	$86,119
	Regulation of Gut Microbiome by Peanut Consumption in Youth with both Gender *(sub-award from UGA)*	4/1/2019	9/30/2022	46,446	46,446
National Agriculture Research Organization /National Semi Arid Resources Research Institute (NARO/NaSARRI)	Integration of High Throughput Phenotyping (HTP) for enhancing Breeding Programs in Senegal, Ghana, Uganda, and Regional Cooperation *(sub-award from VT)*	9/1/2018	11/30/2022	$34,893	$67,657
	Use of Novel Genetic diversity for peanut development in East Africa *(sub-award from UGA)*	9/1/2018	9/1/2021	$32,725	$90,000
	Mapping Groundnut Rosette Virus (GRV) resistance for marker-assisted selection *(sub-award from UGA)*	10/1/2018	9/30/2021	$18,500	$55,000

Institution	Project Name	Start Date (mm/dd/yy)	End Date (mm/dd/yy)	FY2019 Budget	Total Budget
	Identifying the Alternative Host for Groundnut Rosette Disease Virus Complex *(sub-award from UGA)*	8/1/2018	2/1/2021	$42,735	$102,200
	Photovoice for Youth Empowerment in peanut value Chains in Uganda	3.1.2019	2/28/2022	$3,080	$33,440
	Enhancing the Genetic Potential of Peanut Production in Eastern/Southern Africa	2/1/2019	7/31/2022	$33,000	$181,940
	Adoption and implementation of digital management systems and analytical pipeline by groundnut breeding programs in Malawi, Mozambique, and Zambia	5/1/2018	4/30/2019	$140,625	$140,625
	Breeder Seed Production and assessment of Breeding Programs capacity building in targeted African countries	5/1/2018	4/30/2019	$35,415	$35,415
Zambia				$12,000	$46,100
Zambia Agriculture Research Institute (ZARI)	Enhancing the Genetic Potential of Peanut Production in eastern/southern Africa *(sub-award from NARO/NaSARRI)*	2/1/2019	7/31/2022	$0	$34,100
	Breeder Seed Program and assessment of breeding program capacity building in targeted African countries *(sub-award from NARO/NaSARRI)*	5/1/2018	4/30/2019	$12,000	$12,000

Appendix B. Success Stories

New Ghanaian research group builds capacity to share research

Bringing together experts in groundnut research from across Ghana, a new organization of scientists aspires to boost the size of the crop and profit for farmers, improve the quality of groundnuts consumers see at the market and increase the supply of nutritious and safe food served in homes.

A group of Ghanaian researchers and agri-professionals along the value chain met for the inaugural meeting of the Ghana Groundnut Working Group, a gathering that could build capacity throughout the sector.

The Ghana Groundnut Working Group (GGWG) met for the first time in July to explore peanut production, economics, technology and benefits in Ghana. Organizers hope to make the meeting an annual gathering and continue to incorporate business and industry sponsors from all segments of the groundnut value chain.

Sponsored by the Peanut Innovation Lab, the first meeting was organized by Mumuni Abudulai, chief research scientist for CSIR's Savanna Agricultural Research Institute, George Mahama, an agronomist with SARI in Wa; Richard Akromah, professor at Kwame Nkrumah University of Science and Technology; Brandford Mochiah, director of CSIR's Crops Research Institute; and David Jordan of North Carolina State University. The inaugural meeting of the GGWG brought together more than 50 scientists and agricultural professionals from the Council for Scientific and Industrial Research, University Developmental Studies, private industry and foreign partners.

The model for the meeting is the American Peanut Research and Education Society, a 51-year-old organization in the United States that has helped the peanut industry in the Americas weather disease and other production problems over recent decades.

"Several institutions – research institutes, universities, and NGOs – work to promote groundnut production in Ghana by providing technical and managerial assistance to farmers, groups and small-scale entrepreneurs," said Abudulai. "But, the exchange of ideas among these groups and across the groundnut supply chain in Ghana is limited. Several models exist for establishing working groups and professional societies, but the American Peanut Research and Education

Society has been very effective in creating a forum for interactions among all segments of the U.S. peanut industry.

“Based on the success story of APRES, the Feed the Future Innovation Lab and partners in Ghana felt that establishing a similar organization would be valuable to the groundnut sector here.”

While the first meeting of the GGWG included updates on the latest scientific research into variety development, pest control and cropping systems, sessions also explored economics, food safety and child nutrition. In addition to leading experts from the national program and universities, discussions included farmers and aggregators who work growing and processing groundnuts every day.

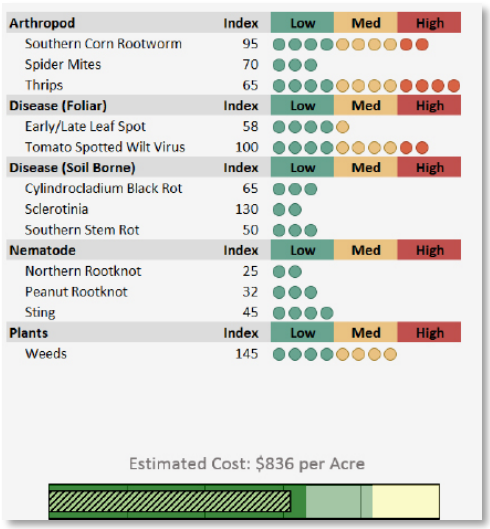
“For the GGWG, you need to have everyone from the value chain at the table. You must look at issues from the seed to the table,” said Akromah, who is an expert in plant breeding and genomics. “My personal interest is in the quality of the seed, but you have to have a diverse group for the GGWG to be successful.”

Peanut Risk Tool helps farmers in U.S. and around the world

Researchers in North Carolina, through the Feed the Future Innovation Lab for Peanut, updated a risk assessment tool that empowers peanut farmers there to decide when a pest, weed or weather condition threatens yield enough to invest in fighting it.

Along with updating the Peanut Risk Tool to be more usable in North Carolina, the work will make the resource available to extension specialists in other countries, as well, giving them the same ability to forecast risk and reward in the field.

The North Carolina Peanut Risk Tool pulls together different stresses that might impact yield in a given year, allowing extension agents and farmers to see how threats may interact with one another and to make wise decisions about inputs and other investments. A particular pest might be threatening any time but combined with other circumstances – late planting and dry weather, for example – could be devastating in a particular year. Knowing how circumstances will work together to impact the crop can help farmers decide when to take action.



The Peanut Risk Tool calculates different risk factors to help farmers decide whether to invest in inputs.

Farmers worry about individual pests and problems, but also understand how multiple circumstances working together can make circumstances worse. Weighing the big-picture risk, farmers can consider the cost and benefit of each input, but it's challenging to see that big picture without a tool.

The tool was originally developed around 2005 with support from the North Carolina Peanut Growers Association and the USDA. That iteration took a written production guide into the digital age, taking advantage of internet accessibility. But over time, the platform became out of date; the data in the tool could only be updated by someone with computer coding skills.

"Now, people like me can update the information regularly and keep the tool current and applicable," said David Jordan, a North Carolina State University peanut extension specialist and principal investigator of the Peanut Innovation Lab's risk tool project and another to create production packages for peanut in Ghana. "In the process people at other institutions across the globe can take the tool and the instructions and make their own tool."

Refining the data to go into the tool – deciding how much weight to give certain pests – can push researchers to think about how stresses compound in the field and agree on the effects.

"Making the tool forces scientists to build consensus. A number has to be entered in a category and cooperating scientists have to think across subject matter disciplines and climates. That's an important intangible that the risk tool fosters cooperation through its construction," Jordan said.

The Peanut Innovation Lab provided funding to update the North Carolina Risk Tool as part of a quick-start project commissioned when the five-year innovation lab program started in 2018.

Using the platform developed at North Carolina State University as a starting point, Jordan and other PIs can apply the technology to help develop risk tools for other countries. Work already is under way to develop a risk tool for Ghana, based on good agricultural practice maps and crop calendars for the production systems in two regions of the country. The proposed project will use the experiences with risk tool development in Ghana and North Carolina to develop risk tools for Malawi, Senegal, and Uganda.

Collaborators across Africa help mine genetic diversity of peanut varieties

A Feed the Future Innovation Lab for Peanut project brought together plant breeders from across Africa to share hundreds of lines of peanut varieties and get the first ever map of the diversity of the plant across the continent.

By mapping peanut diversity, the project has increased understanding the genetic differences in varieties, allowing scientists in the lab to pinpoint genes attached to different resiliency traits and empowering US and African plant breeders to incorporate those traits into new varieties.

The project used a recently completed SNP array for genotypic analysis of different peanut lines, but getting that data depended on cooperation of a diverse group of scientists from across Africa to contribute germplasm.

From all accounts, that collaboration was successful.

African peanut breeders stand in a field in Senegal where seeds were replicated for a project to map the genetic diversity of lines grown on the continent. Scientists genotyped hundreds of lines of peanuts grown across Africa.

The project, spearheaded by University of Georgia scientist Peggy Ozias-Akins, began in 2018, when plant breeders from several African countries – Ghana, Mali, Niger, Senegal and Togo in west Africa and Malawi, Mozambique, Uganda and Zambia in southern and eastern Africa – submitted seed from 1300 peanut varieties grown in their regions. Plants were grown out in Senegal, DNA extracted, and genotyping done in the USA. Scientists evaluated the data to determine the overall diversity of the submitted lines, and to define a subset of lines to evaluate in the field across Africa.

Following months of enthusiastic work, those scientists met this year to review the data, train in how to use the information and take the knowledge home to their own breeding programs.

The project – titled Genotypic analysis of peanut germplasm using the Axiom_Arachis2 SNP array – used the Arachis array (which contains 58,000 unique SNPs), as well as resources available on Peanut Base, a database of peanut genotypic and phenotypic data. Single nucleotide polymorphisms (SNPs) are differences that can be detected between the genomes of two

individuals using modern molecular technology. Arrays that contain thousands of such SNPs are an effective and inexpensive way to determine how similar or different two varieties really are.

At a wrap up meeting, the breeders received all of the SNP data, had the analysis software installed on their laptops, were trained in how to access and analyze the data for use in their future research efforts, and had identified the set of lines for further field trials across Africa. In addition, all of the SNP data was submitted to Peanut Base, making it publicly available to anyone interested in peanut diversity.

The breeders also will receive supplies of seed from all lines submitted for genotyping.

The SNP genotyping is actually the first step of a much larger pair of Peanut Innovation Lab projects led by the national breeders in Senegal and Uganda. This larger project aims to assemble a reference set of lines representing the diversity of peanut across Africa. These lines will then be evaluated in numerous field trials across Africa to identify lines containing genes for traits of interest by the breeders.

Now, Ozias-Akins is genotyping another 2500 lines of African origin that are stored in the USDA germplasm collection in order to determine whether those lines have more or less diversity than those now used in breeding programs. Thirty-six African countries of origin are represented among the selections.

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