

**Feed the Future Innovation Lab for  
Collaborative Research on Sorghum and Millet**

**Annual Performance Report FY 2014**



October 2014



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**FEED THE FUTURE**  
The U.S. Government's Global Hunger and Food Security Initiative

**KANSAS STATE  
UNIVERSITY**

Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet  
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# Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet

## Annual Performance Report FY 2014

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### Cover photo:

*A woman sorghum farmer in the lowland Samre Zone of Ethiopia talks with researchers about best practices in Striga control in August 2014. Photo credit: Nat Bascom.*

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## Acronyms

AANAPISI	Asian American Native American Pacific Islander Serving Institutions
AOR	Agreement Officer Representative
ARS	Agricultural Research Service
ATA	Agricultural Transformation Agency
AWARD	African Women in Agricultural Research and Development
AWG	Agricultural Working Group
BFSF	Bachelor of Science in Foreign Service
BMR	Brown Midrib
CAUSE	Consortium of African and United States Educators
CCRP	Collaborative Crop Research Program
CERAAS	Centre d'Etude Régional pour l'Amélioration de l'Adaptation à la Sécheresse
CGIAR	Consultative Group on International Agricultural Research
CIIFAD	Cornell International Institute for Food, Agriculture and Development
CIRAD	Centre de Coopération Internationale en Recherche Agronomique pour le Développement
CNRA	Centre National de Recherche Agronomique
CORAF/WECARD	West and Central African Council for Agricultural Research and Development
CRP	CGIAR Research Program
CRSP	Collaborative Research Support Program
EAAP	Ethiopian Association of Agricultural Professionals
EAB	External Advisory Board
EAS	Ethiopian Academy of Sciences
EIAR	Ethiopian Institute of Agricultural Research
EMMP	Environmental Mitigation and Monitoring Planning
EMS	Ethyl Methanesulfonate
GFS	Global Food Systems
GRIN	Germplasm Resource Information Network
DNA	Deoxyribonucleic Acid
HBCU	Historically Black Colleges and Universities
HSI	Hispanic Serving Institutions
HX	Heterowaxy
HPD	High Protein Digestibility
ICRISAT	International Crops Research Institute for the Semiarid Tropics
IDIN	International Disease and Insect Nursery
IDLIT	International Drought Line Test
INRAN	Institut National de Recherches Agronomiques du Niger
INTSORMIL	International Sorghum and Millet CRSP
IPM	Integrated Pest Management
ISRA	l'Institut Sénégalais de Recherches Agricole
ITA	Institut de Technologie Alimentaire
KSU	Kansas State University
KWS	Klein Wanzlebener Saatucht,
ME	Management Entity
MHM	Millet Head Miner
MLT	Midge Line Test
MPA	Master of Public Administration
NAM	Nested Association Mapping
NSP	National Sorghum Producers
OSU	Oklahoma State University
PAG	Professional Advisory Group

PI	Principal Investigator
PMP	Performance Monitoring Plan
SICNA	Sorghum Improvement Conference of North America
SME	Small Medium Enterprises
SMIL	Sorghum and Millet Innovation Laboratory
USAID	United States Agency for International Development
USCP	United Sorghum Checkoff Program
UNDP	United Nations Development Program
USDA	United States Department of Agriculture
WAAPP	West Africa Agricultural Productivity Program
WACCI	West African Centre for Crop Improvement
WX	Waxy

## Executive summary

The Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet was established on July 23, 2013 and this report covers the last two months of FY13 and the entire FY14. Activities during this period focused on establishing the management entity (ME) of the Sorghum and Millet Innovation Lab (SMIL) and developing a portfolio of research activities on 1) genetic enhancement of sorghum and pearl millet, 2) production systems management, and 3) added-value product and market development. Following contracting of the subawards, research was initiated during the growing season in West Africa and Ethiopia. In order for the projects to function smoothly, research coordination units were established in Senegal, Niger and Ethiopia.

The management entity of the Sorghum and Millet Innovation Lab consists of a Director, an Assistant Director (hired during FY 13), a program coordinator (hired during Q1 FY14) and a business financial specialist (hired during Q2 of FY14). An external advisory board of five members oversees the program. In all three countries, a small nucleus of support staff consisting of an accountant and a program coordinator assist in local management.

The research program was established through a multi-step approach. First, the ME held priority setting workshops in Niger and Senegal where scientists from the national programs, universities, international centers, private sector and representatives from farmer organizations interacted with the ME to establish and prioritize research topics in each of the countries. A similar workshop was held in Ethiopia prior to program establishment in January 2013. Reports from each of these meetings and a synthesis were published. A call for research concept notes was issued in November 2013 and resulted in the submission of 58 proposals from the United States, Australia, Europe, Africa and Asia. Based upon the external reviews of the submitted concept notes, fifteen were selected to be developed into full proposals.

The full proposals were evaluated by the management entity, the EAB and ad hoc reviewers and ten were selected for funding with six focusing on West Africa and four on Ethiopia. In March and April, meetings were held in Ethiopia and Senegal that brought together all project collaborators. During these meetings, research objectives and operational plans were improved and finalized. These documents were used to develop contractual arrangements between Kansas State University and the subawardees. Approximately \$8.5 million was programmed for research projects and in-country coordination. Research activities were initiated during the growing season and results will be forthcoming during the FY15 as crops have not been harvested.

## I. Management entity information

The Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet is headquartered at Kansas State University in Manhattan, KS. Kansas State serves as the management entity for the program, and is committed to increasing the resiliency of small-scale producers in the face of climate change while linking U.S. and international universities and research organizations in a collaborative effort to make sorghum and pearl millet the crops of the future.

The management entity was formed in July 2013 with the hiring of the Sorghum and Millet Innovation Lab director. The assistant director was hired in September 2013 and the program coordinator and half-time business financial specialist joined the team in early 2014. The management entity has also employed student interns at various periods throughout the year.

The management entity staff includes the following individuals:



### **Timothy J. Dalton – Director**

E-mail: [tdalton@ksu.edu](mailto:tdalton@ksu.edu)

Phone: 1.785.477.8239

Dr. Timothy J. Dalton serves as the Director of the Sorghum and Millet Innovation Lab. Professor Dalton received an A.B. from Columbia University in 1988, an M.S. in Agricultural Economics from the University of Illinois in 1992 and a Ph.D. in Agricultural Economics from Purdue University in 1996. Dr. Dalton's research and development experience in sorghum and millet stretches back 20 years back to a M.S. thesis on dryland sorghum and millet farming systems in the Peanut Basin of Senegal followed by an award-winning doctoral dissertation on the ex-ante economic impact of improved sorghum varieties on soil degradation in Southern Mali (partially funded by INTSORMIL). He is well experienced in interdisciplinary research and specialized in understanding the relationship between agricultural production, technological changes and the environment. He has extensive professional experience in more than 20 African countries.

Dalton has substantive experience with CGIAR research institutes, the Standing Panel on Impact Assessment of the CGIAR, the Food and Agriculture Organization of the United Nations, foundations, USAID and USDA. He is a member of the multistate research project "NCI034 Impact Assessment and Decision Strategies for Agricultural Research" and a member of the Council of Food, Agriculture and Resource Economics Blue Ribbon Panel on Development. In 2012 he led the USAID-commissioned external evaluation of the Peanut CRSP and the AquaFish CRSP. Dr. Dalton is fluent in French.



### **Nat Bascom – Assistant Director**

E-mail: [nbascom@ksu.edu](mailto:nbascom@ksu.edu)

Phone: 1.785.532.2129 or 1.785.477.2804

Nat Bascom serves as the assistant director of the Sorghum and Millet Innovation Lab. He has a master's degree in Agricultural and Biological Engineering (soil and water) as well as in Leadership Studies. Nat has over twenty years of experience in partnership development, program planning, performance monitoring and evaluation of international development activities. He is fluent in French and has experience in managing a regional office operation which supported program delivery with multiple implementing partners and range of donor organizations.





**Kira Everhart-Valentin – Program Coordinator**

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Kira Everhart-Valentin serves as the program coordinator for the Sorghum and Millet Innovation Lab. She holds a B.A. in French, a B.S. in Agricultural Communications and Journalism and an M.A. in Political Science. Much of her Master's-level research focused on the constraints faced by women farmers in francophone Africa. Kira previously served as the International Extension Program Coordinator at Purdue University as well as a marketing consultant for numerous agribusinesses. She is fluent in French.



**Kristen Sanborn – Business Financial Specialist**

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Kristen Sanborn serves as the Business Financial Specialist for the Sorghum and Millet Innovation Lab. She provides all financial analysis, accounting support, travel planning and procurement for the USAID-funded grant. She holds a B.S. in Business Administration and a Masters in Accounting. Previously, Kristen worked as the Accounts Payable Supervisor in the Division of Financial Services at Kansas State University. In addition to her position at KSU, she also has considerable experience in tax and property accounting.

## II. External Advisory Board information

The Sorghum and Millet Innovation Lab's External Advisory Committee (EAB) was formed in the fall of 2013 and currently has five members plus the Sorghum and Millet Innovation Lab's Agreement Officer's Representative (AOR). The EAB's responsibilities include the following:

- Assisting in the review and selection of submitted concept notes and proposals
- Attending an annual on-site EAB meeting at Kansas State University, as well as participation in an annual virtual meeting to discuss project details and progress
- Networking with strategic partners and resource mobilization
- Participation in periodic assessment of the Sorghum and Millet Innovation Lab's progress towards overall research objectives
- Guiding the Sorghum and Millet Innovation Lab in developing its long-term vision and assisting in the implementation of that vision
- Facilitating in-country assessments of the research projects
- Participating at in-country annual review meetings when necessary

The EAB was consulted with regularity during the concept note and proposal selection processes, including a two-day on-site meeting at Kansas State University in December 2013. Teleconferencing was held during the year to discuss project selection and various management issues. The Lab management entity stays in regular communication with the EAB through monthly e-updates highlighting management entity activities and current priorities. The EAB members include:



**Dr. Brhane Gebrekidan**  
Ethiopian Academy of Sciences

Dr. Brhane Gebrekidan has spent a considerable portion of his career in sorghum breeding in his native country of Ethiopia. In the most recent past, he has served and currently serves as a member and/or leader of various professional groups. This service has included Vice President, Founding Fellow and Board Member of the Ethiopian Academy of Sciences (EAS), Chair of the Agriculture Working Group (AWG) of the EAS, Vice Chair of the Professional Advisory Group (PAG) to Colleges of Agriculture of Ethiopian Public Universities, and Vice Chair of the Ethiopian Association of Agricultural Professionals (EAAP). Additionally, he has served as External Board Member of ICRISAT's Sorghum and Millet Project supported by the Gates Foundation. Currently Dr. Gebrekidan also serves as a member of the Agricultural Transformation Agency (ATA) of Ethiopia.



**Prof. Bettina Haussmann**  
*West Africa Liaison Scientist, Researcher and Capacity Development Manager*  
University of Hohenheim and McKnight Foundation

Bettina Haussmann earned a Master's degree in agricultural biology from the University of Hohenheim in Stuttgart, Germany in 1990 and her Ph.D. in 1995, studying the effects of heterozygosity and heterogeneity on the adaptation of sorghum to semi-arid areas of Kenya. She completed her Habilitation in plant breeding in 2004.

As a Ph.D. student and post-doctoral researcher, Haussmann conducted research in Zimbabwe, Kenya and Mali. She was a Fellow at the University of Hohenheim in plant breeding where she conducted research on Striga resistance in sorghum. Haussmann was a private lecturer at the University of Hohenheim teaching plant breeding in the tropics, use of genetic resources and planning of breeding programs. She also served as the senior/principal scientist in pearl millet improvement and gene bank responsibility at the ICRISAT Sahelian Centre in Niamey, Niger.

Presently, Haussmann serves as a part-time Capacity Development Manager at KWS Breeding Company in Einbeck, Germany, monitoring and evaluating KWS' capacity development projects in Ethiopia and Peru. She is also an Extraordinary Professor and private lecturer at the University of Hohenheim's Institute of Plant Breeding. Haussmann serves as the West Africa Liaison Scientist for the McKnight Foundation's Collaborative Crop Research Program (CCRP), working in funding strategy development, project and proposal evaluation, and teaching and coordination of research projects related to plant breeding in the tropics, particularly in Sub-Saharan Africa. Haussmann also supervises Bachelor of Science, Master of Science and Ph.D. students.



**Dr. Tim Lust**  
*Chief Executive Officer*  
National Sorghum Producers

Tim Lust is the Chief Executive Officer of the National Sorghum Producers (NSP) and the United Sorghum Checkoff Program (USCP). In his role with the NSP, Tim works on legislative and regulatory issues that impact the sorghum industry as well as represents the U.S. sorghum industry at events throughout the United States and worldwide. In association with the USCP, Tim works directly with producers, sorghum researchers and marketing specialists to maintain a deep knowledge base of the most current happenings in the industry and to provide increased support for the crop.

Tim grew up on a diversified farming and cattle operation near Lazbuddie, Texas, and received his B.S. in Animal Science from Angelo State University and his MBA from Texas Tech University. He is a past member of the USDA Agriculture Trade Advisory Committee to the Secretary of Agriculture. Tim and his wife Lea Ann have two sons, Ty and Dru.



**Dr. Peter Matlon**

*Adjunct Professor*  
Cornell University

Dr. Peter Matlon is an adjunct professor in the Department of Applied Economics and Management at Cornell University, and chairs the boards of trustees of the Africa Rice Center based in Cotonou, Benin, and the Global Fund for African Women in Agricultural Research and Development (AWARD) based in Nairobi, Kenya. He also serves on the advisory board of the Cornell International Institute for Food, Agriculture and Development (CIIFAD) in Ithaca, New York. Before his retirement in 2007, Matlon served as Managing Director for The Rockefeller Foundation Africa programs, Deputy Director of Rockefeller's Agriculture Program, Chief of the Global Program for Food Security and Agriculture of UNDP, Director of Research at the West Africa Rice Development Association, leader for the West African Economics Program of the International Center for Research in the Semi-Arid Tropics, and Assistant Professor in the Department of Agricultural Economics at Michigan State University.

During his career, Matlon has served on a number of global advisory panels including the United Nations Millennium Program Hunger Task Force and the InterAcademy Council Panel on African Agriculture. He also chaired the United Nations Inter-Agency Working Group on Food Insecurity and Vulnerability Information and Mapping Systems, and was Executive Secretary of the Impact Assessment and Evaluation Group of the Consultative Group on International Agricultural Research (CGIAR).

Matlon earned his Ph.D. in agricultural economics from Cornell University in 1977, an MPA from the Woodrow Wilson School of Public and International Affairs at Princeton University in 1971, and a BSFS degree from the School of Foreign Service at Georgetown University in 1967.



**Dr. Barbara Stoecker**

*Regents Professor and Marilyn Thomas Chair*  
Oklahoma State University

Barbara Stoecker earned her Bachelor of Science degree in home economics from Kansas State University in 1965. She went on to earn her Ph.D. in nutrition with minors in biochemistry and physiology from Iowa State University in 1970 and completed post-doctoral research in nutrition in 1978. She currently serves as Regents Professor for the Department of Nutritional Sciences and Marilyn Thomas Chair in Human Sciences at Oklahoma State University.

Stoecker has held the role of team leader for evaluation of USAID Nutrition Innovation Lab/Asia and the Nutrition Innovation Lab/Africa for Nepal, Malawi and Uganda. She was a member of the OSU Team for development of the Consortium of African and United States Educators (CAUSE), and was responsible for strategic planning meetings in Rwanda, Ethiopia and Kenya. Stoecker presently serves to support the development of the M.S. degree program in Applied Human Nutrition at Hawassa University in Awassa, Ethiopia and is a contributor to the International Curriculum Development Workshop and graduate instructor for AHuN 513 – Nutrition and Metabolism. She completed extensive research in children's nutrition in Ethiopia and Kenya, and supervised a Ph.D. project on complementary food development for infants and young children in rural communities in the Sidama region of Ethiopia. Stoecker has also conducted nutritional research in China, Thailand and Iraq.

Stoecker has served as an associate professor of food and nutrition and Coordinator of Academic Affairs at Texas Tech University, professor and head of the Department of Nutritional Sciences at Oklahoma State University, and interim associate dean of research services for the College of Human and Environmental sciences at Oklahoma State University.

### III. Focus countries

The Sorghum and Millet Innovation Lab will continue the INTSORMIL CRSP tradition of contributing to the alleviation of poverty through technological innovation and human capacity development. However, in a change of approach from its predecessor, SMIL has concentrated its efforts to three focus countries - in the West African nations of Senegal and Niger, and the East African nation of Ethiopia.

Multiple criteria were utilized in the selection of the Lab's three focus countries, which include:

- 1) The current supply of sorghum and millet as compared against projected future demand in 2020,
- 2) The number of impoverished sorghum and millet farmers in each country, the role of sorghum and millet within the national agricultural economies, and opportunities for broad-based farm impact,
- 3) Opportunities for local progress in added-value product development to stimulate demand for sorghum and millet in order to sustain a production revolution and to generate broader impact to consumers, and
- 4) Determination of which countries would benefit the most from Sorghum and Millet Innovation Lab programming by considering where there exists a critical mass of scientists that may capitalize on this support.

In all countries of interest, the prevalence of children younger than 5 years old who are underweight exceeds 20 percent and, in areas where sorghum and millet are commonly grown, this rate can approach 50 percent. The nutritional needs for intervention are high in all countries.

#### A. Ethiopia

- Ethiopia is one of the most important sorghum-producing nations in East Africa. It has the largest acreage of sorghum in East Africa after Sudan.
- Ethiopia is estimated to have 12.3 million sorghum farmers who live on less than \$2 a day. In addition to helping the country's farmers, Ethiopia is one of the centers of genetic origin for sorghum.

#### B. Senegal

- Senegal grows a large area of pearl millet, which is the most widely grown subspecies of millet. Pearl millet has adapted to the harsh semiarid environment in West Africa, especially in areas where few other cereal crops can thrive.
- Researchers are working to improve productivity and add value to pearl millet crops and sorghum. Doing so can help Senegal's 3.5 million millet producers who are economically classified as "ultra poor."

## C. Niger

- Niger is one of the largest sorghum- and pearl millet-producing countries in West Africa, though roughly 8.4 million sorghum farmers in Niger live on less than \$2 a day.
- Niger neighbors several other important sorghum-producing countries in the region, which are expected to economically benefit from the advancements made in Niger.

## IV. List of program partners

### A. United States

Integrated Pest Management Innovation Lab  
 Kansas State University  
 Kansas State University – Hays Research Station  
 Purdue University  
 Texas A&M AgriLife Research  
 Texas A&M University  
 USDA-ARS  
 Virginia Tech University  
 West Texas A&M University

### B. Ethiopia

Ethiopian Institute of Agricultural Research  
*Asosa Research Center*  
*Bako Research Center*  
*Melkassa Research Center*  
*Pawe Research Center*  
*Sirinka Research Center*  
 Haramaya University  
 Hawassa University  
 Holleta Biotechnology Center  
 Oromia Regional Program  
 Tigray Agricultural Research Institute  
 Tigray Regional Program

### C. Senegal

Centre d'Etudes Régional pour l'Amélioration de l'Adaptation à la Sécheresse  
 Centre National de Recherche Agronomique  
 FAPAL (farmer organization)  
 Institut Sénégalais de Recherches Agricoles  
 Institut de Technologie Alimentaire  
 University Cheikh Anta Diop de Dakar

### D. Niger

Fuma Gaskiya (farmer organization)



HALAL (farmer organization)  
 Institut National de la Recherche Agronomique du Niger  
 International Crops Research Institute for the Semi-Arid Tropics  
 LSDS (farmer organization)  
 University of Maradi

## **E. Germany**

University of Hohenheim

## **F. France**

Centre de Coopération Internationale en Recherche Agronomique pour le Développement

## **G. Republic of South Africa**

University of Pretoria

# **V. Program activities and highlights**

## **A. Establishment of research priorities**

The Sorghum and Millet Innovation Lab was contracted on July 23, 2013 and completed the first fourteen months of its program at the end of fiscal year 2014. During the first four months of the reporting period, research priorities were identified in the target countries of Ethiopia, Niger and Senegal through in-country priority setting exercises. An open call for research concept notes was then initiated in response to national needs. Fifty-eight research concept notes were evaluated by the Lab's EAB, the management entity and ad hoc reviewers. Fifteen were selected to be developed into full proposals in December 2013.

## **B. Selection of research portfolio**

Full proposals were developed during the month of January 2014. During this period, the management entity facilitated phone conversations between researchers working on similar topics in order to identify areas for collaboration and to minimize duplications of effort. In February, final selection of projects took place after further evaluation by the EAB, management entity and a larger set of ad hoc reviewers. Four projects were selected for Ethiopia and six projects for West Africa. All projects in West Africa proposed activities for both Niger and Senegal. These ten projects are led by six institutions (Purdue University, Kansas State University, West Texas A&M University, Texas A&M University, ICRISAT and the University of Hohenheim) and collaborate with sixteen additional institutions in Ethiopia and fifteen more institutions in West Africa plus the Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD), based in France.

## **C. Project inception meetings**

Program inception meetings took place in Ethiopia in April and in Senegal in May. The West African inception meeting in Senegal hosted U.S., European, Senegalese and Nigerien researchers, as well as scientists from Burkina Faso and Mali, supported by CORAF. As a result of presentations and discussions at these meetings, along with efforts initiated during the proposal phase to coordinate and collaborate, final project work plans were resubmitted and contracts negotiated and finalized. Final revisions of proposals were requested before contracting in order to ensure that the projects were well aligned with national objectives as well as to allow an opportunity for reorientation. In order to ensure that field activities would be initiated during the growing season, the management entity developed financial bridging arrangements with the Ethiopian Institute of

Agricultural Research (EIAR), the Institut National de la Recherche Agronomique du Niger (INRAN) and the Institut Sénégalais de Recherches Agricoles (ISRA) where each of the research organizations prefinanced research activities while contracts were finalized.

#### **D. Funding distribution across regions and areas of inquiry**

Across the ten funded projects, approximately 57% of project funding will be invested in the genetic enhancement of sorghum and millet, 20% in production systems management and 23% in added-value product development and markets. Of the funds invested in research, 42% of the total will be directed to projects targeting Ethiopia and 58% in projects in Senegal and Niger. In Ethiopia, genetic enhancement activities are led by Gebisa Ejeta, Tesfaye Mengiste and Tesfaye Tesso, production systems management activities are led by co-PIs in Tesfaye Tesso's project and added-value products research is conducted under the project led by Joseph Awika. In West Africa, genetic enhancement research is led by Geoff Morris, Mitch Tuinstra, and Bonnie Pendleton and their respective teams, research on production systems management is conducted under Drs. Malick Ba, Ludger Herrmann, and Bonnie Pendleton while added-value products research is led by Bruce Hamaker. Field trials and experiments were established in all locations during FY 2014; however, results will only become available during the first quarter of FY 2015.

## **VI. Key accomplishments**

### **A. Research prioritization and in-country workshops**

In-country workshops were held in Ethiopia, Senegal and Niger in the fall of 2013 that produced research priority setting reports describing key constraints and opportunities for sorghum and pearl millet research in each nation. These reports were used as the foundation of 58 research concept notes that were submitted for evaluation and later resulted in ten funded research projects. In the second quarter of FY2014, program inception meetings were held in Ethiopia and Senegal (which also included Nigerien scientists) to finalize research project implementation strategies and to update operational plans for the forthcoming cropping season. Fifteen research contracts were developed by Kansas State University with the grantees. Funding allowed for research activities to begin during the end of the third quarter of FY2014.

### **B. Assembly of Ethiopian sorghum germplasm core collection**

Highlights of key accomplishments in Ethiopia include the assembly of a "core" collection of Ethiopian sorghum germplasm by Dr. Ejeta, Dr. Mengiste and Dr. Tesso through collaboration with the Ethiopian Biodiversity Institute. This collaboration opened up access to its database of over 9,000 Ethiopian sorghum germplasm accessions maintained at the institute in addition to online access to over 5,000 Ethiopian sorghum collections available in the USDA GRIN. The PIs also coordinated efforts with local researchers from national and regional research institutes and universities in Ethiopia to develop inventory of locally-grown landraces and released varieties in different regions of the country. All of these resources were used to systematically select and constitute a core germplasm population consisting of 2,500 accessions/genotypes representing diverse geographies of the country, utilization attributes, agronomic adaptation and tolerance to biotic and abiotic stresses. All entries were planted in two locations (Mieso and Melkassa) and a subset of entries planted in the disease-prone areas of Bako, Asosa and Pawe to evaluate host-plant resistance to endemic pathogens. Ethiopian strains of fungal pathogens were obtained and assay conditions were optimized for laboratory analysis.

### **C. Experimental hybrids in adaptive trials, lines being sorted for food product potential**

In addition, 762 experimental hybrids, synthesized at Purdue University, were sent to Ethiopia for adaptive trials in multiple locations. Value-added product development research saw 24 waxy/hetero-waxy high-protein lines harvested by Texas A&M researchers in August with no apparent yield penalty for these traits. These lines are being sorted and characterized to determine their potential role in food products. Two Ph.D. candidates and one M.S. student were identified for long-term training.

#### **D. Genetic enhancement of sorghum initiated in West Africa through multiple mechanisms**

In West Africa, genetic enhancement research has started in Senegal and Niger. A West African panel of sorghum (n=577) with entries from Senegal, Niger and Mali was established and entries grown out and phenotyped. The same entries were grown out under laboratory conditions and DNA extracted in Bambey, Senegal. Existing agronomic data on the entries were assembled. In Senegal, DNA extraction from the nested association mapping population is proceeding. Students have been recruited from Niger and Senegal. EMS-derived mutant populations from Tx623 were evaluated for grain quality traits including more digestible protein, low phytic acid, gelatinization temperature and starch content. These mutants will be used in Ph.D. students recruited to attend the West African Centre for Crop Improvement. Drought, midge and the International Disease and Insect Nursery panels were sent from Texas A&M for evaluation in Senegal and Niger.

#### **E. Millet head miner parasitoids being reared; potential sorghum and millet fortificants collected**

Production systems management research is moving forward in the area of integrated pest management of the millet head miner. Eggs of the parasite were collected in Niger and Senegal and parasitoids were collected as well. Rearing strategies for the parasitoid wasp that controls millet head miner are being optimized and initial research with farmer groups was conducted to establish business models for parasitoid production. Value-added research was initiated in Senegal and nutrient-rich plant materials were collected as natural fortificants for sorghum and millet food products.

### **VII. Research program overview and structure**

The Sorghum and Millet Innovation Lab is structured to address a variety of research topics along the sorghum and millet value chains. Its research program is founded on the following vision:

- To build a coalition of science and industry around sorghum and millet research to reduce poverty and hunger
- Incubate and nurture a new wave of feed and food products to stimulate demand
- Create an economically-rationalized business and research investment plan

Priority areas for research were defined during stakeholder consultations in 2013 in each of the three countries (<http://www.k-state.edu/smil/whatwedo/countries/index.html>). Activities within these research priorities are organized under three areas of inquiry: 1) Genetic enhancement of sorghum and millet; 2) Production systems management; and 3) Added-value product development and markets. Often, projects may not fit neatly into one category or another but are instead interdisciplinary in nature. Additionally, projects contribute to the cross-cutting themes of gender, the environment and nutrition.

In October and November of 2013, SMIL held an open call for concept notes to respond to the research priorities established during stakeholder meetings in Ethiopia, Niger and Senegal. Fifty-eight concept notes were received from investigators based in Africa, the United States, Europe, Asia and Australia. These concept notes were evaluated by the EAB, the management entity and ad-hoc external reviewers. Fifteen concept notes were retained for development into full proposals. The full proposals were then evaluated by the same individuals plus an extended set of ad-hoc reviewers. Based upon the final ranking, ten projects were selected for funding. Approximately \$8.0 million has been allocated to these research projects with a small amount of funding held in reserve for future research opportunities.

Approximately 57% of project funding will be invested into genetic enhancement of sorghum and millet, 20% in production systems management and 23% in added-value product development and markets. Of the funds invested in research, 42% of the total will be invested in projects targeting Ethiopia and 58% in projects in Senegal and Niger. All projects in West Africa have components in both Niger and Senegal.

Currently, the Sorghum and Millet Innovation Lab has not identified a strong project that focuses on pearl millet genetic enhancement. However, the management entity anticipates commissioning research in this area in 2015. In addition, funding has been allocated for commissioned research in the cross-cutting theme on gender.

Projects are led by several institutions including Purdue University (four projects), Kansas State University (two projects), Texas A&M, West Texas A&M, ICRISAT and the University of Hohenheim (one project each). These projects are associated with 16 collaborating institutions in West Africa and another 16 collaborating institutions in Ethiopia (Figure below), as well as one collaborating institution in France.

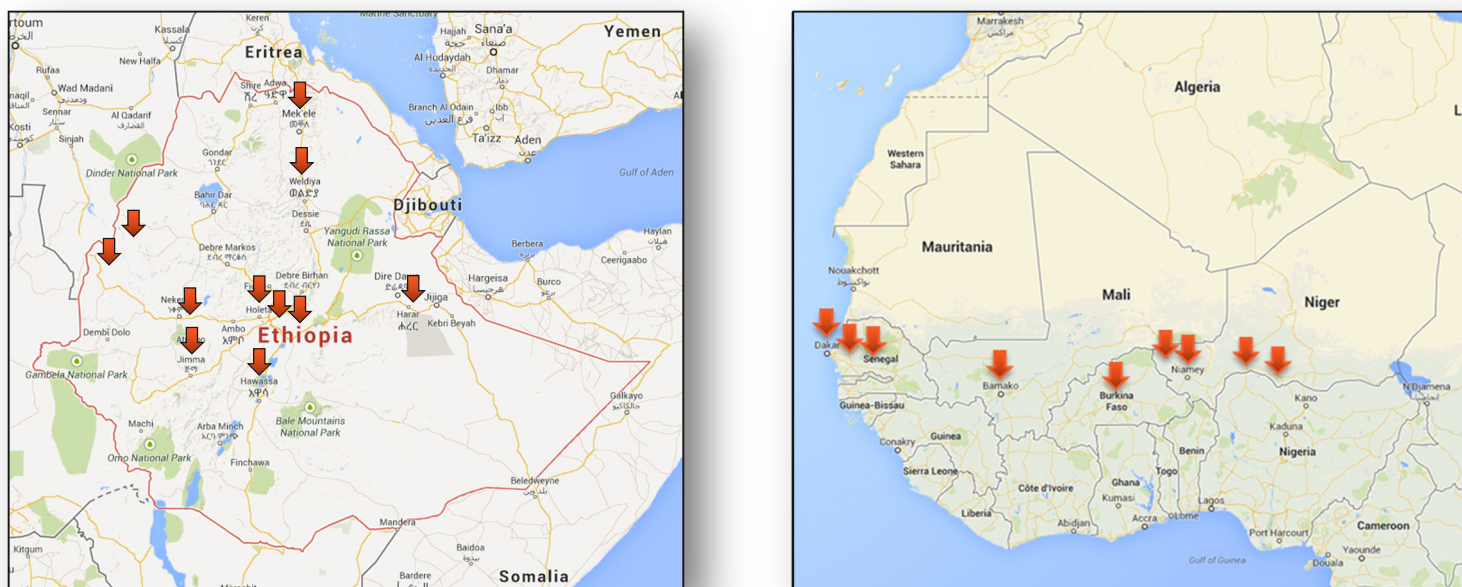


Figure 1. Sorghum and Millet Innovation Lab research activity locations in Ethiopia and West Africa

## VIII. Research project reports

Final selection of the Sorghum and Millet Innovation Lab's ten research projects was made in February 2014, with inception meetings hosted in March through May 2014. Contracting took place during the summer. Activities and/or planting has been initiated among all projects, with several implementing their first planting season during this reporting period.

## A. Ethiopia

### 1. *Developing superior functionality in sorghum for food applications to promote sorghum value chain in Ethiopia* (Led by Dr. Joseph Awika – Texas A&M University)



#### Area(s) of inquiry:

Added-value products and markets  
Genetic enhancement

#### Description

Two major bottlenecks on sorghum utilization for food in Ethiopia's growing urban markets are its inadequate functionality as a food ingredient and inferior protein nutritional quality (low lysine and poor digestibility). To combat these characteristics, Texas A&M University has developed a set of sorghum parental lines and hybrids that combine waxy and

heterowaxy traits (WX/HX) with the high lysine, high protein digestibility (HPD) trait into high performing hybrids and inbred cultivars. The WX/HX-HPD sorghums have desirable end-use characteristics, including more efficient fermentation for ethanol, better protein quality co-product (high lysine) for feed and other uses, and better functionality in batters and dough systems. In this project, Dr. Awika and his research team will test the hypothesis that the improved WX/HX-HPD sorghums will demonstrate significantly better functionality as a food ingredient in dough and batter systems, producing superior quality grain-based products, and that products made with WX/HX-HPD sorghums will demonstrate superior protein nutritional quality for infants and young children from poor households.

The three research objectives for this project include:

- 1) Establish the effect of combining waxy-heterowaxy (WX/HX) with HPD sorghum traits on dough and batter rheology, food processing, and quality profile of selected traditional and commercial grain-based food products popular in Ethiopia;
- 2) Establish the suitability of the WX/HX-HPD sorghum hybrids for malting and commercial brewing; and
- 3) Evaluate the performance and adaptation of the WX/HX-HPD sorghum hybrids in Ethiopia.

Addressing these objectives will lead to development of superior quality sorghum-based food products that will open new markets and enhance the value-chain of sorghum, benefit small-scale sorghum producers and small- and medium-scale food enterprises (SMEs), and limit the effects of poor nutrition in children.

#### Collaborators

U.S. collaborating institution(s): Texas A&M University  
Intl. collaborating institution(s): Ethiopia - Hawassa University  
South Africa - University of Pretoria

#### Achievements

Steps for determining whether waxy/heterowaxy (WX/HX) and high lysine, high protein digestibility (HPD) lines are useful for human food products were initiated in the 2014 growing season in College Station, Texas. Twenty-four lines were harvested in August 2014 and the grains are being cleaned and sorted so that analytical measures of grain quality attributes (hardness, density, thousand kernel weight, color, milling properties) can be conducted in FY 2015. In addition to these grain quality attributes, the grain endosperm functional characteristics (solubility indices, starch pasting and swelling, batter viscosity and stability, and water absorption) will be evaluated as will the grain protein content and amino acid profiles of materials grown in both Ethiopia and Texas. Field notes indicate that there is no apparent yield



penalty for improved endosperm lines (WX/HX or HPD lines) when compared against checks. Two Ph.D. students were identified for training at Texas A&M University and the University of Pretoria.

#### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Awika was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late March in Adama, Ethiopia, which involved approximately 40 researchers from a variety of regional and national research stations in Ethiopia. Together, Awika's team dedicated nearly two days to solidifying their research project's operational plan and addressing key issues related to sorghum's potential for food applications.

Additionally, this project plans to train two graduate students from Ethiopia at the Ph.D. level. These training programs are set to begin in 2015 and will include one student at Texas A&M University in the U.S. and another at the University of Pretoria in South Africa.

#### Lessons learned

Grain yields from breeding lines with waxy, heterowaxy and high protein digestible traits do not appear to be lower than those without the WX/HX-HPD traits.

#### Presentations and publications

Awika, J. "Developing superior functionality in sorghum for food applications to promote sorghum value chain in Ethiopia." Sorghum and Millet Innovation Lab Inception Meeting. Rift Valley Hotel, Adama, Ethiopia. 26 March 2014. Project Presentation.

## **2. Genetic enhancement of sorghum to promote commercial seed supply and grain market development in Ethiopia (Led by Dr. Gebisa Ejeta – Purdue University)**



#### Area(s) of inquiry:

Genetic enhancement  
Added-value products and markets

#### Description

Ethiopian sorghum landraces exhibit native genetic variation for drought and Striga resistance which this project aims to exploit in the development of sorghum cultivars with resistance to these important stresses. The project employs biotechnology, breeding and agronomy to unleash the potential of the crop for Ethiopian farmers. The team is developing a core set of sorghum germplasm population to characterize the inherent

variability through large-scale, high-throughput genotyping and coupling this practice with phenotyping of valuable traits under target environments. Data is then treated with appropriate bioinformatics and statistical procedures to identify useful allelic variation for drought and Striga resistance. This will be enhanced by the development of local capacity and the restoration of rigor and discipline to the Ethiopian sorghum breeding program to produce superior sorghum on a regular basis. Project researchers will cooperate with agronomists and economists to develop a package of genetic and crop management practices to control stresses and optimize yields.

At the highest level, the project aims to develop a functional sorghum breeding program in Ethiopia focused on the development of adapted, high-yielding sorghum varieties and hybrids for broad societal impact. The use of hybrid cultivars will be promoted to strengthen the seed supply value chain and catalyze the development of a commercial sorghum seed enterprise system in the country. These activities will serve as part of the larger national effort in building local capacity, strengthening the institutions of education, research, extension, and input systems for development, and for advancing science-based development to impart livelihood change for smallholder sorghum farmers of Ethiopia.

### Collaborators

U.S. collaborating institution(s): Purdue University, Kansas State University  
 Intl. collaborating institution(s): Ethiopia - Ethiopian Institute of Agricultural Research (EIAR), (Melkassa Research Center, Sirinka Research Center), Holleta Biotechnology Center, Tigray Regional Program, Oromia Regional Program, Haramaya University

### Achievements

With Drs. Tesfaye Mengiste and Tesfaye Tesso a core set of Ethiopian landraces, released varieties, hybrids, and near wild relatives was established in collaboration with regional collaborators and the Ethiopian Institute of Biodiversity Conservation. This team drew upon the collection of 9000 accessions maintained at the institute as well as the 5000 entries available at the USDA GRIN. This effort resulted in a core germplasm population consisting of 2500 accessions/genotypes representing diverse geographies of the country, utilization attributes, agronomic adaptation and tolerance to biotic and abiotic stresses. Seeds of these materials were acquired from different sources and the population planted at two locations in Ethiopia (Mieso and Kobo) during the 2014 main agricultural season. These materials were planted during the FY2014 and are being evaluated during the first quarter of FY15. In addition to developing the core collection, this project sent 762 experimental hybrids, synthesized at Purdue University to Ethiopia for adaptive testing in multiple locations.

### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Gebisa was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late March in Adama, Ethiopia, which involved approximately 40 researchers from a variety of regional and national research stations in Ethiopia. Together, they dedicated nearly two days to forming a solid, collaborative research project that would address the most compelling issues in sorghum drought and Striga resistance.

### Lessons learned

Complex and large scale nurseries were planted in multiple locations in Ethiopia as were synthesized hybrids developed at Purdue University. While formal evaluation of breeding lines will take place in FY2015, the Ethiopian research partners were able to implement the research test plots and screen entries despite a very tight time schedule.

### Presentations and publications

Ejeta, G. "Genetic enhancement of sorghum to promote commercial seed supply and grain market development in Ethiopia." Sorghum and Millet Innovation Lab Inception Meeting. Rift Valley Hotel, Adama, Ethiopia. 26 March 2014. Project Presentation.

## **3. Genetic improvement of sorghum and millet for resistance to fungal pathogens (Led by Dr. Tesfaye Mengiste – Purdue University)**



### Area(s) of inquiry:

Genetic enhancement

### Description

Sorghum is an important food security crop in Ethiopia, and is grown in diverse agroecologies with varying climatic characteristics. While some of the most favorable conditions for crop growth occur in west Ethiopia, these conditions are also accompanied by a variety of potentially devastating pathogens.

The goal of the project is to enhance sorghum productivity and improve the livelihood of sorghum farmers in western Ethiopia through a collaborative research program focused on developing new, innovative interventions in crop disease resistance. Local varieties grown in the target regions have evolved under

severe pathogen pressure and thus possess powerful alleles for a blend of novel resistance genes. Fungal diseases, anthracnose and grain mold are significant risk-causing pathogens in the target region that can result in significant loss of yield, grain quality deterioration, and are obstacles to growing high yielding varieties with shorter growth durations.

By utilizing the unique local gene pool and other sources of germplasm covering the spectrum of natural variation, this project aims to identify disease resistance to combine with other adaptive traits to create high yielding sorghum varieties and hybrids. This will be achieved through innovative phenotyping and resistance breeding, supported by molecular tools for identification and characterization of genes and alleles in key genomic regions underlying a higher level of disease resistance. The germplasm evaluations that make use of the unique environmental conditions of the target region will be strengthened by next generation sequencing and mapping approaches to identify genes underlying quantitative traits such as grain mold. In parallel, to guide the breeding effort and enhance resistance identification schemes, the prevalence and nature of fungal species causing grain mold and strains of anthracnose in the target area will be studied. Further, the project aims to strengthen the capacity of local research institutions by providing graduate education in critical areas that are likely to boost the capability of the next generation of breeders and plant pathologists.

#### Collaborators

U.S. collaborating institution(s): Purdue University, Kansas State University  
 Intl. collaborating institution(s): Ethiopia - EIAR (Asosa Research Center, Pawe Research Center, Bako Research Center), Holleta Biotechnology Center

#### Achievements

As described under Dr. Ejeta's project, an Ethiopian cores set of germplasm was assembled from numerous sources and were planted in two locations where they will be evaluated for biotic stress resistance. In addition, a set of 25 different sorghum hybrid parental lines from the Ejeta lab collection were sent to three additional locations known for high endemic disease pressure (Bako, Pawe and Assosa) for screening against anthracnose and grain mold. Evaluation of these materials will take place in October 2014. In order to conduct evaluation under controlled conditions, the project developed (and will continue to develop) assay conditions and disease screen protocols to be implemented under greenhouse conditions at Purdue University. This required identification of sources of the relevant Ethiopian strains and their acquisition from other universities and will contribute to identification of resistance genes that might be used in recombinant inbred lines.

#### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Mengiste was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late March in Adama, Ethiopia, which involved approximately 40 researchers from a variety of regional and national research stations in Ethiopia. Together, they dedicated nearly two days to forming a solid, collaborative research project that would address the most compelling issues in sorghum fungal pathogens.

Additionally, this project plans to train one Ph.D. student and one M.S. student at Purdue University during the project period. Final details on the start dates for those trainings have not been decided.

#### Lessons learned

Screening for disease resistance will be conducted in FY15 but several lines were damaged by cold stress due to the late plantings in Bako. This was fortuitous because known cold-tolerant lines were not as severely affected. This may be important if short-duration varieties offering the opportunity to double crop and plantings occur during periods where cold stress may hamper stand establishment.

#### Presentations and publications

Mengiste, T. "Genetic improvement of sorghum and millet for resistance to fungal pathogens." Sorghum and Millet Innovation Lab Inception Meeting. Rift Valley Hotel, Adama, Ethiopia. 26 March 2014. Project Presentation.

**4. Improved crop genetics, production practices and processing methods for increased productivity and nutrition for smallholder sorghum producers in Ethiopia** (Led by Dr. Tesfaye Tesso – Kansas State University)



Area(s) of inquiry:

Genetic enhancement  
Production systems management

Description

This project focuses on developing and utilizing high-yielding, locally-adapted sorghum varieties and hybrids that are rich in highly-digestible protein and essential micronutrients, while at the same time suiting local processing methods and diverse production systems. Through collaborative sorghum research, new innovations including the recently completed sequence of the sorghum genome, fine mapping of loci

associated with Striga resistance, discovery of biochemical compounds associated with processing and utilization of sorghum grains, and the development of herbicide-resistant sorghum can be utilized and explored.

Multidisciplinary teams of scientists from a variety sorghum research institutions in Ethiopia, the USDA-ARS and U.S. land grant universities will work together to exploit the wide genetic resources for high yield potential, environmental stress tolerance and improved nutritional quality available among Ethiopian sorghum germplasm. The team also plans to optimize food processing methods in order to maximize availability of nutrients in sorghum-based local diets. A series of interrelated activities will be implemented both in the laboratory and at selected field locations in major sorghum producing regions of the country to discover unique phenotypes related to improved productivity, protein and micronutrient nutrition and develop and select the best variety or hybrid carrying these traits.

The team also plans to utilize genomic tools to locate genes associated with enhanced nutritional value and reduced anti-nutritional factors, such as low protease inhibitor and phytic acid, and enhance breeding efforts for the improvements of many of these traits. Additionally, the team will contribute to building the capacity of human resources and the institutional infrastructure of collaborating national organizations through training and mentoring graduate students to help build the critical mass of scientists capable of solving local and national problems.

Collaborators

U.S. collaborating institution(s): Purdue University, Kansas State University, USDA-ARS, KSU – Hays Research Station  
Intl. collaborating institution(s): Ethiopia - EIAR (Melkassa Research Center, Sirinka Research Center, Pawe Research Center), Tigray Agricultural Research Institute, Haramaya University

Achievements

As described above, this project contributed to the development of the Ethiopian core germplasm collection with specific aims at systematic evaluation of the population for nutritional and quality traits. Core germplasm population of Ethiopian sorghum representing diverse ecologies, adaptation and quality profile have been developed. The population will serve as key resources for breeding and genetic study of Ethiopian sorghum to facilitate the improvement of the crop in the country. Because of their adaptation to conditions specific to the country, local sources are preferred for use as breeding materials while sources of novel traits from elsewhere are welcome. The ongoing characterization of the population will thus help identify founding lines/genotypes to initiate variety and hybrid breeding efforts in the country that is entirely based on local germplasm.



### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Tesso was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late March in Adama, Ethiopia, which involved approximately 40 researchers from a variety of regional and national research stations in Ethiopia. Together, they dedicated nearly two days to forming a solid, collaborative research project that would address the most compelling issues in sorghum yields, environmental stresses and nutritional quality.

Additionally, this project plans to train two Ph.D. students (one at Kansas State and another in Ethiopia) and three M.S. students in Ethiopia during the project period. Final details on the start dates for those trainings have not been decided.

### Lessons learned

Planting of nurseries was successful in all locations yet careful synchronization of parental lines with differing cycle lengths is required so that male and female lines can be crossed.

### Presentations and publications

Tesso, T. "Improved crop genetics, production practices and processing methods for increased productivity and nutrition for smallholder sorghum producers in Ethiopia." Sorghum and Millet Innovation Lab Inception Meeting. Rift Valley Hotel, Adama, Ethiopia. 26 March 2014. Project Presentation.

## **B. West Africa**

### ***1. Improving sorghum adaptation in West Africa with genomics-enabled breeding (Led by Dr. Geoffrey Morris – Kansas State University)***



#### Area(s) of inquiry:

Genetic enhancement

#### Description

Improving the productivity, resilience and quality of cereal crops is a major leverage point for development in West Africa because of the potential for impacts in regional trade, rural food security, and the health of women and children. As the starting point for a major agriculture value chain, enhanced sorghum varieties with greater yields and improved yield stability can support agricultural and economic development at regional scale.

This project will use new genomic tools to accelerate marker-assisted breeding and expand its impact in West Africa, with six integrated objectives:

- 1) Genomic characterization of Senegalese and Nigerien landraces and breeding lines to connect West African breeding programs to global sorghum breeding efforts;
- 2) Development of a simplified genomics toolkit to increase access to marker-assisted breeding tools in West Africa;
- 3) Development of multi-parent populations for more efficient trait mapping and breeding which combine traits from locally-preferred varieties and elite global lines;
- 4) Improved genetic mapping of stress resistance/tolerance traits to generate more effective trait-associated markers;



- 5) Implementation of Marker Assisted Recurrent Selection to develop more resilient locally-preferred varieties;
- 6) Long-term and short-term training on genomics-enabled breeding for West African crop scientists.

As sorghum is a major component of the diet of many of sub-Saharan Africa's poorest rural people, the acceleration of sorghum breeding will have numerous outcomes that support Feed the Future objectives. In particular, the proposed project will directly address the USAID strategy for climate-smart agriculture in West Africa by accelerating the development of sorghum varieties with increased resilience to abiotic and biotic stressors.

#### Collaborators

*U.S. collaborating institution(s):* Kansas State University

*Intl. collaborating institution(s):* France - Centre de Coopération Internationale en Recherche Agronomique pour le Développement (CIRAD)  
 Senegal - Institut Sénégalais de Recherches Agricoles (ISRA), Centre d'Etudes Régional pour l'Amélioration de l'Adaptation à la Sécheresse (CERAAS), Centre National de Recherche Agronomique (CNRA)  
 Niger - International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Institut National de la Recherche Agronomique du Niger (INRAN), LSDS (farmer organization), HALAL (farmer organization)

#### Achievements

Seedling growth and DNA extraction is underway for the Senegalese germplasm at Bambey but not in Niger due to research infrastructure limitations. This information will be used to develop a Genotyping-by-Sequence SNP map for West African germplasm. In addition to this activity, a Nested Association Mapping (NAM) population of F3 plants was sampled for their DNA and the generation advanced to the F4 population. A West Sahelian Association Panel was assembled (n=577) from Senegalese, Nigerien and Malian entries and sown at Bambey, Senegal. Phenotyping is in progress during the 2014 cropping season. Two Ph.D. students were identified for training at Kansas State University.

#### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Morris was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late April in Saly, Senegal which involved approximately 45 researchers from a variety of research institutions in Senegal, Niger, Mali, Burkina Faso, France, Germany and the U.S. Together, Morris's team dedicated nearly two days to solidifying their research project's operational plan and addressing key issues related to the establishment of a genomics-enabled breeding program.

Additionally, this project plans to train two graduate students from Niger and Senegal at the Ph.D. level. These training programs are set to begin in 2015 at Kansas State University and will include one year of English language training before commencing research activities. One student is from Niger and the other from Senegal.

#### Lessons learned

Burkina Faso was invited to contribute entries into the West Sahelian Association Panel however they were not permitted to export their entries outside of the country.

#### Presentations and publications

Morris, G. "Improving sorghum adaptation in West Africa with genomics-enabled breeding." Sorghum and Millet Innovation Lab Inception Meeting. Hotel Royal Saly, Saly, Senegal. 23 April 2014. Project Presentation.

## 2. **Development of biotic stress-resistant sorghum cultivars for Niger and Senegal** (Led by Dr. Bonnie Pendleton – West Texas A&M University)



### Area(s) of inquiry:

Genetic enhancement  
Production systems management  
Added-value products and markets

### Description

This multi-disciplinary research project will include entomology, breeding, and agricultural economics to develop, evaluate, and deploy sorghum genotypes resistant to abiotic and biotic stresses and adapted to indigenous production and storage systems in West Africa. An integrated approach will increase agricultural productivity and economic growth, with attention to human nutrition, environmental conservation, development of host-country capacity, and gender equity.

In this project, sorghum genotypes with resistance to important stressors in West Africa and the U.S will be selected for managing abiotic and biotic constraints. Sorghums that flower when sorghum midges are present in the field will be evaluated to develop resistance to sorghum midge. Research on sorghum time of flowering in relation to environmental factors will be used to verify the genetic basis of resistance.

Additionally, germplasm resistant to grain mold and weathering in a range of environments will be introgressed into sorghums adapted to Niger and Senegal. To protect stored grain, environmentally friendly methods including hermetic storage and plants with natural insecticidal properties will be evaluated. Scanning electron microscopy of the structure of sorghum kernels resistant to storage insects will be used to increase efficiency for evaluating sorghum genotypes for resistance.

Extension will assist in teaching farmers to identify and manage biotic constraints in the field and storage. Human capacity will be improved by educating scientists in conventional and molecular research methodology and in graduate degree programs. Production profitability and marketing opportunities for sorghum cultivars with increased resistance to abiotic and biotic stresses will be assessed to ensure farmer adoption in West Africa. In all, this project is improving human nutrition, human capacity, and environmental conservation while increasing productivity and economic growth for sorghum.

### Collaborators

U.S. collaborating institution(s): West Texas A&M University, Texas A&M AgriLife Research  
Intl. collaborating institution(s): Senegal - ISRA, CNRA, CERAAS  
Niger - INRAN

### Achievements

Initial activities in West Africa were started through the transfer of three sets of sorghum lines to be screened in Niger and Senegal: the International Disease and Insect Nursery (IDIN – 25 entries\*1 row\*2 repetitions), the International Drought Line Test (IDL – 30\*1\*2 repetitions) and the Midge Line Test (50\*1\*3 repetitions). The intent with the nurseries is to provide a diverse array of germplasm that may/should be useful to the collaborating programs. The IDIN has known standards for adaptation, yield and resistance to drought and selected diseases or insects as well as grain weathering. The IDLT has known standards for pre- and post-flowering drought tolerance. The MLT has a diverse set of sorghum midge resistant germplasm from the Texas AgriLife breeding program. These entries were sent to both countries and are under evaluation.

### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Pendleton was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late April in Saly, Senegal which involved approximately 45 researchers from a variety of research institutions in Senegal, Niger, Mali, Burkina Faso, France, Germany and the U.S. Together, Pendleton's team dedicated nearly two days to solidifying their research project's operational plan and addressing key issues related to the development of biotic stress-resistant sorghum cultivars.

Additionally, this project plans to train two graduate students from Niger and Senegal at the M.S. level. These training programs are set to begin in 2015 and 2016 respectively at West Texas A&M University with additional research activities occurring at their home institution.

### Lessons learned

The project is in a start-up phase and no specific lesson have been identified.

### Presentations and publications

Almas, L., Cisse N., Kadi Kadi, H., Mamadou, Sarr, I., **Pendleton, B.**, Peterson, G. "Development of biotic stress-resistant sorghum cultivars for Niger and Senegal." Sorghum and Millet Innovation Lab Inception Meeting. Hotel Royal Saly, Saly, Senegal. 23 April 2014. Project Presentation.

## **3. Trait development pipeline for food and feed value in sorghum (Led by Dr. Mitchell Tuinstra – Purdue University)**



### Area(s) of inquiry:

Genetic enhancement

### Description

Some of the most important regional research issues highlighted by scientists in Niger and Senegal as related to sorghum include the need to develop locally-adapted guinea and non-guinea sorghum varieties and hybrids with improved grain quality characteristics. This project leverages new genetic technologies to address these sorghum crop improvement needs through targeted research, short- and long-term training and education, and technology transfer to promote and enhance sorghum

production and impact.

The genetic research and technology transfer in this project makes use of the sorghum genome sequence and a proven population of sequence-indexed mutants as tools to identify and characterize allelic variation in genes that influence four specific grain quality traits, which include protein digestibility, reduced phytic acid content to improve iron bioavailability, modified starch composition, and designer starches with altered gelatinization temperatures. Collaborators in West Africa are conducting research to target modification of grain protein digestibility and forage quality. Those alleles that condition improved end-use value will then be incorporated into locally adapted cultivars and hybrids.

The project's training activities will strengthen sorghum breeding programs across the region and contribute to capacity building in host-country programs while germplasm-enhancement activities will result in technology transfer that contributes to the development of sorghum varieties and hybrids with enhanced food- and feed-quality traits. Farmer participation in evaluation and selection of these varieties will promote acceptance and production of new cultivars and the increased production of high-quality grains will stimulate and support development of new markets.

### Collaborators

U.S. collaborating institution(s): Purdue University

Intl. collaborating institution(s): Senegal - Institut de Technologie Alimentaire (ITA), CERAAS, ISRA, CNRA  
Niger - INRAN

### Achievements

Mutant plants from nine EMS families were putatively identified as having more highly digestible protein. In addition, reverse genetic analyses identified 60 EMS mutations in genes known to contribute to variations in starch composition or content of cereal crops. Gene candidates were mined from studies in maize, rice, and wheat. More than 30 of these mutants produced enough grain for laboratory analyses of starch content and composition. These results will be verified with grain produced in 2014. Preliminary results indicated numerous genotypes that produce high- or low-amylose starch. Candidate SNPs were identified for causative mutations in each EMS line. The EMS mutant populations were sent to Niger and Senegal for phenotype evaluation and Purdue PIs have initiated breeding crosses to incorporate new sorghum traits into locally adapted sorghum varieties.

Researchers from Niger indicated an interest in working on dual purpose sorghums with improved forage quality based on the brown midrib (BMR) phenotype. Forward genetic screens were used to identify EMS mutations in genes for protein digestibility and brown midrib forage quality traits identified by our collaborators in West Africa. Researchers from Senegal indicated an interest in working on the newly identified sorghum mutants with highly digestible protein. One student each from Niger and Senegal were recruited for graduate training at WACCI.

### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Tuinstra was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late April in Saly, Senegal which involved approximately 45 researchers from a variety of research institutions in Senegal, Niger, Mali, Burkina Faso, France, Germany and the U.S. Together, Tuinstra's team dedicated nearly two days to solidifying their research project's operational plan and addressing key issues related to the issues surrounding developing varieties with improved grain characteristics.

Additionally, this project plans to train two graduate students from Niger and Senegal at the Ph.D. level. These training programs are set to begin in 2015 at the University of Ghana in the WACCI program and will include one year of English language training before commencing research activities.

### Lessons learned

Considerable variation in the mutant populations presents several opportunities to identify production traits that might be addressed through the mutant population in addition to the grain quality traits.

### Presentations and publications

Tuinstra, M. "Trait Development Pipeline for Food and Feed Value in Sorghum." Sorghum and Millet Innovation Lab Inception Meeting. Hotel Royal Saly, Saly, Senegal. 23 April 2014. Project Presentation.

Tuinstra, M. "Functional Genomics Platform for Sorghum Crop Improvement." University of Queensland, Brisbane, Australia. 6 August 2014. Invited Presentation.

#### 4. **Biological control of the millet head miner in Niger and Senegal** (Led by Dr. Malick Ba – ICRISAT, Niger)



##### Area(s) of inquiry:

Production systems management

##### Description

The Millet Head Miner (MHM) is a major chronic insect pest of millet in the Sahel. This project will serve to develop technologies for controlling the MHM, with intentions to significantly decrease the devastating losses that it can inflict (often ranging from 40-85%) on millet yields. Improved management of this key pest will result in increased pearl millet productivity and greater income and food security among millet farmers.

The proposed project includes three primary components:

- 1) Biological control of the MHM with releases of larval parasitoids to significantly increase on-going mass rearing of the larval parasitoid *Habrabracon hebetor* Say (Hymenoptera: Braconidae) and fine-tune release techniques for improved control of the MHM.
- 2) Test the Trichogrammatoidae egg parasitoid as bio control agents of the MHM.
- 3) Establishing parasitoid cottage industry for rearing and commercialization of parasitoids in the Sahel with particular attention to having those businesses owned and operated by individuals or groups of women.

The project will train one M.S. and two Ph.D. students at Virginia Tech as well as the University Cheikh Anta Diop in Senegal. Farmers will be trained on biological control of the millet head miner and links will be made with a McKnight-funded project in Burkina Faso, Mali and Niger, a West-Africa Agricultural Productivity Program-funded project in Senegal and the CGIAR research program on Dryland Cereals to scale up the technologies in all Sahelian countries. Outcomes of this project will include a reduction in pearl millet grain losses, an increase in food production and security among Nigerien and Senegalese millet farmers, as well as the establishment of a cottage industry to rear and sell natural enemies, which will provide revenue to farmers and women's cooperatives.

##### Collaborators

U.S. collaborating institution(s): Virginia Tech University, IPM Innovation Lab

Intl. collaborating institution(s): Senegal - ISRA, CERAAS, University Cheikh Anta Diop de Dakar  
Niger - University of Maradi, INRAN

##### Achievements

Millet head miner eggs were collected from several locations and the populations are being maintained for research purposes. This is particularly challenging because the parasitoid emerges during a narrow window of time. Alternative rearing strategies for the parasitoid wasp (*H. hebetor*) were evaluated to maximize the number of offspring and trials established to determine the best feeding regime for population growth. At the field level, experiments were established to determine the optimal time for releasing *H. hebetor* (panicle exertion, flowering, grain filling) as well as the best time during the growth cycle of the millet head miner (for example when the moths appear or after the appearance of the eggs). At the same time, the social science team held focus group discussions with farmers in Niger in order to discuss business models that could deliver *H. hebetor* to locations with sufficient economic pest pressure. One key issue is that the wasp acts as a public good because of its range (approximately 15 km) and free-riding can occur since the overall demand for a village can be quite limited. In a second field visit, the same issues were raised and a cooperative business model where the farmers' association undertakes the rearing was proposed. Two M.S. students and one Ph.D. student were recruited for training.



### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Ba was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late April in Saly, Senegal which involved approximately 45 researchers from a variety of research institutions in Senegal, Niger, Mali, Burkina Faso, France, Germany and the U.S. Together, Ba's team dedicated nearly two days to solidifying their research project's operational plan and addressing key issues related to the release of parasitoids for control of the millet head miner.

Additionally, this project plans to train four graduate students – two from Niger, one from Senegal and one from the U.S. These include two Ph.D. and two M.S. students and will be located at Virginia Tech University, the Université Cheikh Anta Diop in Dakar, Senegal and the Université Abdou Moumouni in Niamey, Niger. All training programs are set to begin in 2015.

### Lessons learned

The non-excludable public-good nature of the IPM technology will require economic collaboration among farmers that is facilitated by membership in cooperatives. This suggests that the technology will require either public intervention for dissemination or collective action through farmer cooperatives for implementation.

### Presentations and publications

Ba, M. "Biological control of the millet head miner in Niger and Senegal." Sorghum and Millet Innovation Lab Inception Meeting. Hotel Royal Saly, Saly, Senegal. 23 April 2014. Project Presentation.

## **5. Optimization of the seed ball technology for pearl millet, and agronomic and socio-economic evaluation in the context of smallholder farmers in Senegal and Niger (Led by Dr. Ludger Herrmann - University of Hohenheim)**



### Area(s) of inquiry:

Production systems management

### Description

Pearl millet farmers in Senegal and Niger face many challenges related to crop production, one of which is seeding survival. Technologies that enhance seedling survival in the Sahel present the potential of an important contribution to reduce overall cropping risks in the region, thereby enhancing pearl millet productivity and yield stability.

This project pursues the seed ball technology as a valid option to reduce cropping risks and improve farmers' yields - particularly for female farmers - by using low-cost resources that are readily available. The seed ball technology represents a special form of seed pelleting with natural loam and additives including wood ash from cooking places and chemical fertilizers in micro-dosages, to enhance early plant establishment and plant development. In a highly interdisciplinary and participatory approach the team's research activities will:

- 1) Further optimize the seed ball technology for pearl millet;
- 2) Validate the seed ball technology under Sahelian field conditions and determine the agronomic and socio-economic benefits for farmers; and
- 3) Strengthen local capacity for seed ball research and application in Senegal and Niger.

These objectives are being achieved by including smallholder farmers, farmer organizations, local and international research institutions and multimedia in a continued process of seed ball development, refinement, validation and adaptation to local conditions. At least four local Master's students will be trained and results will be communicated widely. The overarching project objective will be achieved when Sahelian subsistence farmers are able to create seed balls independently and can benefit from a reduced likelihood of cropping failures, improved early plant establishment and grain yield formation.

#### Collaborators

Intl. collaborating institution(s): Senegal - ISRA, FAPAL (farmer organization)  
Niger - INRAN, Fuma Gaskiya (farmer organization)

#### Achievements

The University of Hohenheim had delays in identifying an existing graduate student to support this research at Hohenheim. This project was then contracted in October 2014. As a result, project activities will be initiated in FY15 and therefore no notable achievements were made.

#### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Herrmann was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late April in Saly, Senegal which involved approximately 45 researchers from a variety of research institutions in Senegal, Niger, Mali, Burkina Faso, France, Germany and the U.S. Together, Herrmann's team dedicated nearly two days to solidifying their research project's operational plan and addressing key issues related to the field testing of the proposed seed ball technology.

Additionally, this project plans to train four M.S. students from Niger and Senegal – all in-country. Final details regarding these trainings are currently being solidified, but they are currently set to begin in 2015.

#### Lessons learned

Due to the late project initiation date, there is no specific data to report for this section.

#### Presentations and publications

Herrmann, L. "Optimization of the seed ball technology for pearl millet, and agronomic and socio-economic evaluation in the context of smallholder farmers in Senegal and Niger." Sorghum and Millet Innovation Lab Inception Meeting. Hotel Royal Saly, Saly, Senegal. 23 April 2014. Project Presentation.

## **6. Expanding markets for sorghum and millet farmers in West Africa through strengthening of entrepreneur processors and nutrition-based promotion of products (Led by Dr. Bruce Hamaker – Purdue University)**



#### Area(s) of inquiry:

Added-value products and markets

#### Description

This project expands activities with entrepreneurial processors at local incubation centers to develop strategies to fabricate new extruded products, innovative ways to promote processed sorghum and millet products, and nutrient fortification of food products through sustained market demand. The specific project objectives include:

- 1) To further develop and optimize food items made from sorghum and millet for market expansion with a focus on high quality flour-based and agglomerated products, and newly developed technology for the production of nutritionally-enhanced extruded instant flours for thin porridges target at infant/young children.
- 2) To strengthen the capacity of Senegalese and Nigerien micro-, small- and medium-sized agribusinesses through existing incubation centers and to identify development partners for business management training and assistance to entrepreneurs, through improved branding, marketing and promotional activities.
- 3) To leverage nutritional factors in marketing and promotion of sorghum and millet products in rural and urban centers.
- 4) Integrate with other actors in the value-chain to benefit smallholder farmers through development of output markets.

While addressing the area of inquiry, “Development of added-value products and market development,” the research team aims to create successful models using food and nutrition-related technologies to expand markets and improve nutrition and health of vulnerable groups. Scientific and technological research is being used to generate advancements in sorghum and millet utilization while capacity building is incorporated through short-term and graduate degree training.

#### Collaborators

U.S. collaborating institution(s): Purdue University  
 Intl. collaborating institution(s): Senegal - ISRA, CNRA, ITA  
 Niger - INRAN

#### Achievements

Nutrient-rich plant materials that might be used for food fortification were collected in Senegal. In conjunction with the McKnight Foundation, a baseline assessment will be made of micronutrient levels and bioaccessibility for frequently consumed foods and for processed foods. Analyses will be done at Purdue of collected samples and selections made for further studies. In Senegal, the assessment will be conducted as an overlap activity with the Food Processing and Post-Harvest Handling Innovation Lab but with an emphasis on different target populations (urban versus rural). Select micronutrient profiling will be done on traditional, nutrient dense African plant materials (e.g., amaranth, baobab, pumpkin leaf, wild jute, cowpea leaves, spider flower) as well as materials for processing streams from commonly consumed fruits and vegetable (mango and carrots). Processing methods for select nutrient-dense plant foods that are appropriate to the host-countries, will be evaluated, and concentration methods developed for use as powdered fortifying agents.

#### Capacity building

Due to the relatively recent launch of this project, no formal short-term or long-term training has yet taken place. However, Dr. Hamaker was an active participant in the Sorghum and Millet Innovation Lab inception meetings in late April in Saly, Senegal which involved approximately 45 researchers from a variety of research institutions in Senegal, Niger, Mali, Burkina Faso, France, Germany and the U.S. Together, Hamaker’s team dedicated nearly two days to solidifying their research project’s operational plan and addressing key issues related to the development of additional market opportunities for sorghum and millet farmers.

Additionally, this project plans to train two graduate students – one from Niger and one from Senegal – at Purdue University. Both will be trained at a Ph.D. level and are set to begin their program in 2015.

#### Lessons learned

There are numerous sources of beneficial micronutrients in locally available fruits and vegetables but not all of them are stable to be included as natural fortificants in food products.

### Presentations and publications

Hamaker, B. “Expanding markets for sorghum and millet farmers in West Africa through strengthening of entrepreneur processors and nutrition-based promotion of products.” Sorghum and Millet Innovation Lab Inception Meeting. Hotel Royal Saly, Saly, Senegal. 23 April 2014. Project Presentation.

## **IX. Associate award project reports**

The Sorghum and Millet Innovation Lab did not have any associate awards in FY 2014.

## **X. Human and Institutional Capacity Development**

Human and Institutional Capacity Development (HICD) is an integral element of the Sorghum and Millet Innovation Lab’s vision of building a coalition of science and industry around sorghum and millet research to reduce poverty and hunger. Research project activities began in the summer 2014 and the management entity is working with project PIs to develop a variety of in-country short-term trainings and web-based presentations.

### **A. Short-term training**

Short-term training will be emphasized in years 2-5 of the SMIL program. Because contracting of research projects and funding occurred in the later part of the fiscal year, no official short-term trainings occurred in FY2014. However, all PIs and co-PIs have been encouraged to incorporate seminars, workshops and other trainings into their activities. In addition to scientific training, the ME will conduct trainings on a variety of topics for administrative support staff at the various national institutions to build capacity in communications, accounting, data management and other pertinent topics.

### **B. Long-term training**

Due to the fact that the research projects began activities in the summer of 2014, there is no long-term training currently underway. However, the first long-term training experiences are set to begin in January 2015, with several more scheduled in subsequent semesters.

### ***I. Ethiopia outlook***

#### M.S. level trainees

Student	Lead PI	Training institution	Program start date
TBD	Tesfaye Mengiste	Purdue University	TBD
TBD (3 students)	Tesfaye Tesso	In Ethiopia	TBD

#### Ph.D. level trainees

Student	Lead PI	Training institution	Program start date
Tadesse Fikre	Joseph Awika	Texas A&M University	2015
Abadi Gebre Mezgebe	Joseph Awika	University of Pretoria	2015
TBD	Tesfaye Mengiste	Purdue University	TBD
TBD	Tesfaye Tesso	Kansas State University	TBD
TBD	Tesfaye Tesso	In Ethiopia	TBD

## 2. Senegal outlook

### M.S. level trainees

Student	Lead PI	Training institution	Program start date
TBD	Ludger Herrmann	In-country	2015
TBD	Ludger Herrmann	In-country	2015
TBD	Bonnie Pendleton	West Texas A&M University, in-country	2015

### Ph.D. level trainees

Student	Lead PI	Training institution	Program start date
Mame Fatou Goudiaby	Malick Ba	Université Cheikh Anta Diop	2015
Fallou Sarr	Bruce Hamaker	Purdue University	2015
Fanna Mamadou	Geoffrey Morris	Kansas State University	2015
Elisabeth Diatta	Mitchell Tuinstra	University of Ghana (WACCI)	2015

## 3. Niger outlook

### M.S. level trainees

Student	Lead PI	Training institution	Program start date
Oumou Moumouni	Malick Ba	Université Abdou Moumouni	2015
TBD	Ludger Herrmann	In-country	2015
TBD	Ludger Herrmann	In-country	2015
TBD	Bonnie Pendleton	West Texas A&M University, in-country	2016

### Ph.D. level trainees

Student	Lead PI	Training institution	Program start date
Laouali Amadou	Malick Ba	Virginia Tech University	2015
Moustapha Moussa	Bruce Hamaker	Purdue University	2015
Fanna Mamadou	Geoffrey Morris	Kansas State University	2015
Seyni Diakité Ousmane	Mitchell Tuinstra	University of Ghana (WACCI)	2015



## 4. USA outlook

### M.S. level trainees

Student	Lead PI	Training institution	Program start date
Michael Guerci*	Malick Ba	Virginia Tech University	2015

*\*Preference for all long-term trainees has been placed on students from the Sorghum and Millet Innovation Lab focus countries. However, Dr. Ba made a compelling argument for the need for Mr. Guerci's training and its implication on the overall success of Dr. Ba's project objectives.*

## C. Institutional development

Strengthening the institutional capacity of our national agricultural research partners is an objective for the Sorghum and Millet Innovation Lab. Numerous partnerships have been developed in all three focus countries with the goal of a long-term engagement in multiple areas such as technical research support, communications, environmental compliance, gender in development, project monitoring, financial administration, resource mobilization and information knowledge management.

Subaward agreements with the Ethiopian Institute of Agricultural Research (EIAR), the Institut National de Recherches Agronomiques du Niger (INRAN) and the Institut Sénégalais de Recherches Agricole (ISRA) are in place and serve as the conduit for funding in-country research activities as well as national research program coordination functions. The national programs in Ethiopia, Niger and Senegal will be the focus point for distribution of research funds to all collaborating institutions in their respective countries. National program coordinators and accounting staff have been identified and hired in both Niger and Senegal with Sorghum and Millet Innovation Lab funding support. Hiring for equivalent positions in Ethiopia was still in process at the end of FY2014. Vehicles and other essential equipment are also being provided to the national partners in order to strengthen their program coordination and monitoring capacity. With these partnerships and key staff in place, additional training and skills transfer opportunities will be identified in the future.

In order to facilitate the hiring of administrative support staff in Ethiopia, SMIL staff visited EIAR to interview accountant candidates and to explore options for hiring a program coordinator. This provided the opportunity for developing relationships with other support units at EIAR including planning and monitoring, human resources, communications, finance and administration, and gender. The immediate human capacity needs and longer-term capacity strengthening considerations were discussed.

On September 26, 2014, INRAN held a one-day public start-up meeting for the SMIL program in Niamey. The project meeting was attended by USAID, the U.S. Embassy, the Nigerien Minister of Agriculture as well as officials from Maradi, Tillaberry and Dosso. Radio, television and print media covered the event.

## XI. Technology transfer and scaling partnerships

### A. Project technology transfer developments

The ten projects selected for funding by the Sorghum and Millet Innovation Lab were chosen with a strategic outlook on their technology development processes and expected delivery of new technologies or food products. Many of the seed technologies will be developed over the long term while crop management and protection, food products and processing knowledge will be developed over the short- and intermediate-term (see Figure 2).

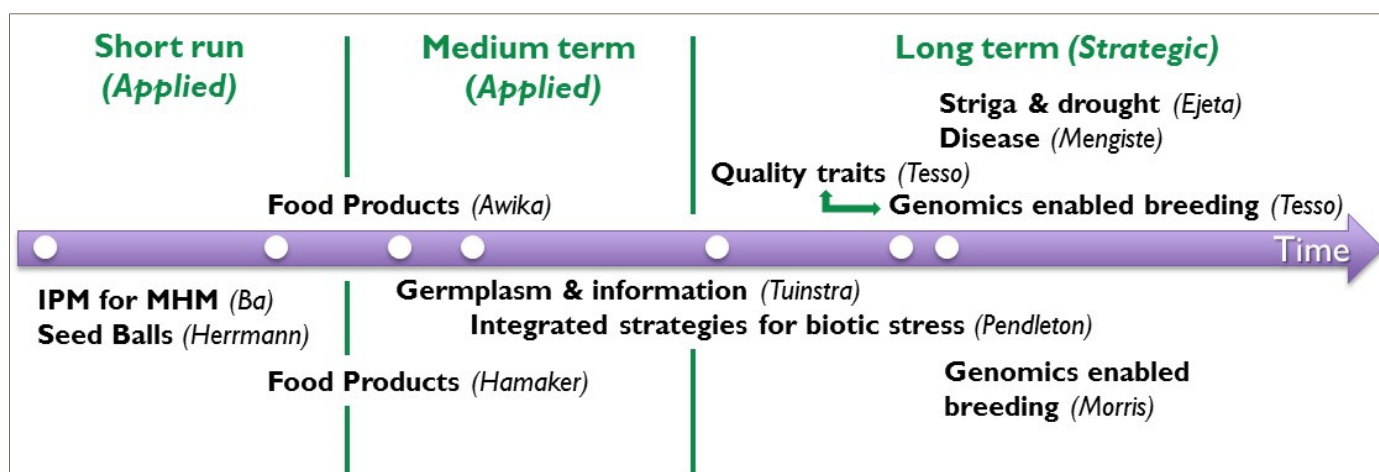


Figure 2. Sorghum and Millet Innovation Lab expected product availability timeline

## B. Additional scaling partnerships

The Sorghum and Millet Innovation Lab has initiated collaboration with organizations that are not directly funded under its competitive research grants. An initial opportunity is occurring through a partnership with Dr. Donna Cohn of Hampshire College, who received funding from the Bill and Melinda Gates Foundation to develop low-tech pearl millet threshers. Dr. Cohn does not have broad collaboration with pearl millet research institutes and approached the Sorghum and Millet Innovation Lab for assistance in developing linkages with research, small-scale implement manufacturers and the target beneficiary for testing and subsequent technology refinement.

The Sorghum and Millet Innovation Lab will facilitate testing and evaluation of hand- and bicycle-powered threshers in Niger in November 2014. Drs. Cohn and Dalton will travel to Niger and work with INRAN scientists on quantitative and qualitative assessments of the efficiency and effectiveness of the mechanical threshers under local conditions. The team will then present the machine to local implement producers and University of Niamey engineers for evaluation and replication. Resulting grain quality will be evaluated by in-laboratory conditions and by consumers and processors. Based upon findings from this visit, the machine will be refined by Dr. Cohn. Subsequent evaluations will take place by Dr. Cohn in Ghana in early 2015.

## XII. Governance and management entity activity

The Feed the Future initiative to reduce global hunger and improve food security through research, education and outreach serves as the platform for the Sorghum and Millet Innovation Lab's goals and activities. With a focus on collaboration and capacity building, the Lab has established three interrelated objectives that comprise its programmatic priorities and overall vision:

- Build a coalition of science and industry around sorghum and millet where structure and opportunity can create entrepreneurial advances to reduce poverty and hunger,
- Incubate and nurture a new wave of feed and food products to stimulate demand for sorghum and millet thereby extending economic benefits beyond the farm gate into the broader population, and
- Create an economically rationalized business and research investment plan to leverage U.S. Agency for International Development core financing and attract broader donor support.

The projects selected for funding by the Lab all fall within these objectives and contribute to the overall Feed the Future goals of reducing global hunger and improving food security. Through scientific advances in production and the enhancement of entrepreneurial opportunities along the value chains, the Sorghum and Millet Innovation Lab is innovating science to make sorghum and millet the crops of the future.

## **A. External Advisory Board**

The Sorghum and Millet Innovation Lab established a competency-based External Advisory Board (EAB) of five members with clear terms of reference. In addition to providing regular guidance to the management entity, the EAB was also critically involved in the review of the 58 concept notes and final selection of ten research projects for funding. Their involvement was facilitated through the use of a web-based proposal review system, phone conferences and face-to-face meetings.

All EAB members have an extensive history of working in key issues and geographic areas that fall within the Sorghum and Millet Innovation Lab's priorities and vision, giving the group a strong working knowledge of the focus countries and sorghum and millet value chains. The EAB meets annually at the management entity headquarters of Kansas State University to review management entity activities, set research priorities and provide guidance on any other key questions or concerns. Monthly updates are provided to the EAB by the management entity in an e-blast form.

## **B. Adaptive management**

The overall management objective of the Sorghum and Millet Innovation Lab is to “develop a management team, systems, and approach that supports improved management performance” as stated in the Performance Monitoring Plan (PMP). With this objective in mind, the management entity has put into place a responsive, well-balanced team to provide support and guidance to the funded projects while focusing energies on developing stronger collaboration within the broader sorghum and millet research communities.

In order to facilitate more efficient and responsive management interaction, a web-based reporting and management platform has been developed. In addition, defined financial management and reporting systems have been instated at both the management entity and national partner level with regular interaction between various administrative actors. Moreover, the management entity has worked closely with principal investigators, in-country investigators, program coordinators and national leadership to support new approaches and methods to ensure an adaptive management that responds to research developments and needs.

## **C. SMIL Resource & Reporting Hub**

The SMIL “Resource & Reporting Hub” has been developed as a web-based platform to support project management functions. Through this platform, users input reporting data which can then be queried to generate reporting needs and to monitor progress on project activities. It also serves as a central location for submitting and tracking all travel and equipment requests by project researchers. The hub is accessible to all PIs, their identified co-investigators, country coordinators and the Sorghum and Millet Innovation Lab's AOR. Webinar trainings have been provided to all PIs on the use of the system, and it was utilized for the first FY2014 reporting period in September 2014. The reporting hub currently has eleven different data collection modules, and the system will continue to develop according to needs (Figure 3).



Figure 3. Screenshot of the SMIL resource and reporting hub interface

## D. Collaborative inception meetings

Upon final selection of the ten projects in the Sorghum and Millet Innovation Lab's research portfolio, the management entity organized three-day in-country inception meetings in order to spur project launch and provide research teams the opportunity to work together on solidifying work plans and clarifying roles and responsibilities. The inception meetings for Ethiopia-based projects took place in March 2014 in Adama, Ethiopia and the meetings for Senegal/Niger-based projects took place in April 2014 in Saly, Senegal. These meetings included principal investigators and their respective national co-investigator teams as well as leadership from the national research systems, regional agricultural research entities and USAID specialists and administrative representatives. Structured interactive trainings in the areas of gender in development, environmental compliance, research for impact, administration and reporting were provided during these inception meetings, as were numerous opportunities for collaborative interaction. The Senegal meetings also included representatives from regional organizations, including CORAF and WAAPP, as well as scientists from Mali and Burkina Faso, thus enhancing the potential for wider impact and increased interaction across West Africa.

## E. Prioritizing cross-cutting issues: Gender

Gender integration is prioritized by the Sorghum and Millet Innovation Lab. The management entity is addressing this cross-cutting issues in a number of ways. These include:

- Prioritizing those project proposals that presented a clear gender strategy during the selection process
- Inviting USAID gender specialists to both project inception meetings to facilitate gender planning sessions and provide direct feedback to researchers on their proposed projects
- Allocating a set amount of funds from the operating budget (\$60,000) to be dedicated specifically towards addressing specific gender-related issues that arise within the research proposal

- Providing project-specific guidance on the identification of key gender-related issues and the development of strategic activities to address those issues
- Identifying opportunities to facilitate scaling opportunities for technologies targeted towards women working along the sorghum and millet value chains, such as the low-tech millet thresher developed by Dr. Cohn (as described in XI. B.)

Efforts in this area will continue to grow as additional opportunities are identified.

## **F. Building relationships within the research and development communities**

As a new actor in the sorghum and millet research and development communities, the Sorghum and Millet Innovation Lab has taken the opportunity to interact with key players in those communities in order to establish the necessary collaborative relationships for future success. As a part of this, the Lab has had an active presence in a number of conferences and professional meetings, including:

- In-country research prioritization meetings – October 1-4, 2013 – Dakar, Senegal
- Innovation Lab Council Meeting – October 14-15, 2014 - Des Moines, IA
- In-country research prioritization meetings – October 23-26, 2013 – Niamey, Niger
- CORAF Science Week – June 16-20, 2014 – Niamey, Niger (by representation)
- Sorghum Improvement Conference of North America – June 25-27, 2014 – Corpus Christi, TX
- Innovation Lab Council meeting – September 17-18, 2014 – Washington, D.C.
- Innovation Marketplace (Frontiers in Development) – September 18-19, 2014 – Washington, D.C.

In addition, the Sorghum and Millet Innovation Lab regularly interacts with other sorghum and pearl millet research organizations including the United Sorghum Checkoff Program (USCP), ICRISAT, the CGIAR Dryland Cereals CRP, the Bill and Melinda Gates Foundation and various other Innovation Labs (including the Kansas State Labs of Wheat Genomics, Reduction of Post-Harvest Loss and Sustainable Intensification). Timothy Dalton serves on the Research Management Committee of the Dryland Cereals CRP and on the High Value Products Committee of the USCP.

## **G. Hosting the 2015 Sorghum Improvement Conference of North America**

One goal of the Sorghum and Millet Innovation Lab is to facilitate greater interaction and linkages within the sorghum and millet research communities. In line with this goal, the Lab will lead Kansas State University in the hosting of the 2015 Sorghum Improvement Conference of North America (SICNA) in Manhattan, KS in August of 2015.

# **XIII. Issues**

## **A. Kansas State University's investment in Feed the Future and global food systems**

In recent years, Kansas State University has reinvigorated its investment and focus on international programs. As a part of this has come a cross-campus Global Food Systems initiative (<http://www.k-state.edu/globalfood/>) that aims to capitalize on the university's agricultural heritage, food systems expertise and world-class research facilities to establish the institution as a leader in addressing the growing technological, educational and human resource needs of the global food system.

The establishment of the Sorghum and Millet Innovation Lab – along with the three subsequent Innovation Labs –aligns with this initiative. The heightened awareness and support for the initiative have allowed the four labs – both individually



and collectively – to leverage multiple resources and services from all levels of the university. Kansas State Research and Extension recruited a pearl millet breeder in FY 2014 that will start in January 2015 as part of its cost-sharing commitment to the Sorghum and Millet Innovation Lab.

## **B. Refining the Kansas State University subcontracting process**

The Sorghum and Millet Innovation Lab management entity has worked closely with the Kansas State University pre- and post-award departments throughout the project subcontracting process to ensure that all contract standards and post-award compliance is addressed from all angles. Numerous lessons were learned during the subcontracting process and specific areas of refinement were identified. The Sorghum and Millet Innovation Lab, along with other Kansas State Innovation Labs with subcontracting responsibilities, is working with the university to improve the overall subcontracting system to allow for a faster, more efficient process in the future.

## **C. Project-level support visits planned**

Support visits by the management entity to the contracted U.S. universities are planned for the first quarter of the fiscal year 2015. These visits will include interaction with the principal investigators around research and administrative issues as well as meetings with other relevant administrative support teams and institutional leadership. Further orientation on reporting deliverables, management expectations and other related implementation questions will also take place. Similar visits will take place in Senegal, Niger and Ethiopia.

## **D. Management of environmental mitigation and monitoring**

The Sorghum and Millet Innovation Lab's Initial Environmental Examination was compiled and approved by USAID early in the reporting period as the research portfolio was selected. Environmental Mitigation and Monitoring Planning documents (EMMPs) have been developed by project and the management entity is actively monitoring the implementation of these documents. A module is currently in development in the SMIL Resource & Reporting Hub that will provide an easily-accessible method for PIs and co-PIs to report back against their project's EMMP, while facilitating the management entity's ability to provide support and monitor project activity.

## **E. Summary of funded projects and subcontracts**

Ten research project subawards were contracted during the fiscal year 2014 with a total value of nearly \$8.0 million. Eight of these projects are led by U.S. universities, while two are led by international institutions. Across the ten funded projects, approximately 57% of project funding will be invested in the genetic enhancement of sorghum and millet, 20% in production systems management and 23% in added-value product development and markets. Of the funds invested in research, 42% of the total will be directed to projects targeting Ethiopia and 58% in projects in Senegal and Niger. In Ethiopia, genetic enhancement activities are led by Gebisa Ejeta, Tesfaye Mengiste and Tesfaye Tesso, production systems management activities are led by co-PIs in Tesfaye Tesso's project and added-value products research is conducted under the project led by Joseph Awika. In West Africa, genetic enhancement research is conducted by Geoff Morris, Mitch Tuinstra, and Bonnie Pendleton and their respective teams, research on production systems management is conducted under Drs. Malick Ba, Ludger Herrmann, and Bonnie Pendleton while added-value products research is led by Bruce Hamaker. Field trials and experiments were established in all locations during FY 2014; however, results will only become available during the first quarter of FY 2015. Table 1 summarizes the funding commitments by project and country-level expenditures. Funding to U.S. universities includes tuition fees and other student support costs which will be reallocated to specific countries as soon as student enroll in long-term training. Funds that are allocated to Ghana are for student training at the West African Center for Collaborative Crop Improvement and for South Africa are student support costs at the University of Pretoria. In-country coordination costs are projected to amount to \$459,029 or about 5% of the host-country expenditures. A summary of these expenditures is presented in Table 1.

Table 1. Funding summary by project and target country

		Country Total									
									U.S.		
Project Title	Principle Investigator	Ethiopia	Ghana	Mali	Niger	Senegal	South Africa	Germany	Int'l Student Training	U.S.	Project Total
	Coordination	214,500	-	-	189,329	55,200	-	-	-	-	459,029
Improving sorghum adaptation in West Africa with genomics-enabled breeding	Geoff Morris	-	-	37,197	199,640	289,221	-	-	246,941	317,094	1,090,093
Combining high digestible protein trait with waxy/heterowaxy endosperm traits to develop superior functionality in sorghum for food applications to promote sorghum value chain in Ethiopia	Joseph Awika	200,003	-	-	-	-	90,000	-	141,012	378,926	809,941
Biological control of the millet head miner in Niger and Senegal	Malick Ba	-	-	-	306,426	120,175	-	-	140,816	71,371	638,788
Development of biotic stress-resistant sorghum cultivars for Niger and Senegal	Bonnie Pendleton	-	-	-	108,721	90,000	-	-	345,057	332,506	876,284
Expanding markets for sorghum and millet farmers in West Africa through strengthening of entrepreneur processors and nutrition-based promotion of products	Bruce Hamaker	-	-	-	153,990	134,000	-	-	249,681	278,657	816,328
Genetic improvement of sorghum for resistance to fungal pathogens	Tesfaye Mengiste	117,700	-	-	-	-	-	-	278,226	447,037	842,963
Optimization of the seed ball technology for pearl millet, and agronomic and socio-economic evaluation in the context of smallholder farmers in Senegal and Niger	Ludger Herrmann	-	-	-	68,334	55,770	-	48,496	-	-	172,600
Genetic Enhancement of sorghum and millets to promote commercial seed supply and grain market development in Senegal and Ethiopia	Gebisa Ejeta	159,500	-	-	-	-	-	-	171,513	581,690	912,703
Improving crop genetics and processing methods for increased productivity and nutrition for smallholder sorghum producers in Ethiopia	Tesfaye Tesso	191,400	-	-	-	-	-	-	120,000	510,021	821,421
Sorghum trait development pipeline for improved food and feed value	Mitch Tuinsta	-	210,000	-	149,500	149,500	-	-	201,024	334,299	1,044,323
	Total	883,103	210,000	37,197	1,175,940	893,866	90,000	48,496	1,894,270	3,251,601	8,484,473

## XIV. Future Directions

Research projects have been initiated and field activities were established during FY14 but full evaluation and harvests will not be complete until FY2015. In Ethiopia, the combined germplasm nursery established by Ejeta, Tesso, Mengiste and collaborators will be evaluated and, based upon findings, will be reconducted during FY15. Screening of synthesized hybrids and parental lines will be conducted during the winter and also during next growing season. Waxy/heterowaxy and high protein digestible lines will be evaluated in Ethiopia and their grain quality attributes assessed for incorporation into food products. No major redirections are expected for research in Ethiopia. Likewise, in West Africa, research projects were initiated and initial activities implemented in all projects except for Herrmann's, which was contracted in FY2015. Germplasm screening took place under several projects, community-level development of integrated pest management techniques were investigated and the collection of locally-available food fortificants conducted. Initial results from these activities will be forthcoming in FY15 as results from the past cropping season are collected. It is expected that 17 new students (12 Ph.D. and 5 M.S.) will enroll in courses during FY 2015.

The SMIL ME will focus on consolidating lessons learned during the start-up phase of the program and concentrate on renewing and modifying subcontracts. The ME will visit with the nearly all PI's during the first quarter of FY15 in preparation for issuing modifications to their contracts. In addition, visits with the program coordinators and accountants in each of the target countries will be conducted to determine whether any changes need to be implemented on the contracts.

The ME will likely fund a project on pearl millet improvement in West Africa. Millet breeders from Senegal, Mali, Niger and Burkina Faso have developed a concept note that focuses on evaluating millet germplasm for forage and grain quality. Past efforts have not emphasized screening for forage quality. The project will also take advantage of pearl millet breeding and cereal forage quality expertise at Kansas State University. As part of its cost share commitment to the program, Kansas State University recruited a pearl millet breeder to reinvigorate its pearl millet improvement program at the Western Kansas Agricultural Research Station in Hays. This scientist will start in January 2015. We expect that a project will be in place for the 2015 cropping season.

## XV. Appendix A: Award Listing to U.S. Universities

Table 2. Award listing to U.S. universities

Project Name	Principle Investigator	Begin	End	U.S. Institution	Funding - CY		Funding - 5 Year Total		AANAPISI	HBCU	HSI
					U.S.	Other	U.S.	Other			
Improving sorghum adaptation in West Africa with genomics-enabled breeding	Geoff Morris	4/1/2014	7/22/2018	KSU	137,608	194,862	564,035	526,058	x	x	x
Combining high digestible protein trait with waxy/ heterowaxy endosperm traits to develop superior functionality in sorghum for food applications to promote sorghum value chain in Ethiopia	Joseph Awika	4/1/2014	7/22/2018	TAMU	75,474	65,946	519,938	290,003	x	x	x
Biological control of the millet head miner in Niger and Senegal	Malick Ba	4/1/2014	7/22/2018	Virginia Tech	11,422	118,288	212,187	426,601	x	x	x
Development of biotic stress-resistant sorghum cultivars for Niger and Senegal	Bonnie Pendleton	4/1/2014	7/22/2018	WTAMU, TX Agrilife	49,481	29,941	677,563	198,721	✓	x	x
Expanding markets for sorghum and millet farmers in West Africa through strengthening of entrepreneur processors and nutrition-based promotion of products	Bruce Hamaker	4/1/2014	7/22/2018	Purdue	46,547	76,758	528,338	287,990	x	x	x
Genetic improvement of sorghum for resistance to fungal pathogens	Tesfaye Mengiste	4/1/2014	7/22/2018	KSU, Purdue	34,995	13,200	725,263	117,700	x	x	x
Genetic Enhancement of sorghum and millets to promote commercial seed supply and grain market development in Senegal and Ethiopia	Gebisa Ejeta	4/1/2014	7/22/2018	Purdue	59,533	11,000	753,203	159,500	x	x	x
Improving crop genetics and processing methods for increased productivity and nutrition for smallholder sorghum producers in Ethiopia	Tesfaye Tesso	4/1/2014	7/22/2018	KSU, USDA	7,837	20,900	630,021	191,400	x	x	x
Sorghum trait development pipeline for improved food and feed value	Mitch Tuinsta	4/1/2014	7/22/2018	Purdue	82,886	256,000	535,323	509,000	x	x	x

## XVI. Appendix B: Success stories

### **STORY #1**

#### **Setting the stage for entrepreneurial growth**

*Technology incubation centers increase competitiveness of local food processing industries; offer nutritious meal options*

Demand for value-added products made from local grains is high in West Africa, but few entrepreneurs have access to the capital needed to create, test and produce new products in order to build their business. To respond to this need, Purdue University food scientist Bruce Hamaker - along with his research teams in the U.S., Senegal and Niger – is expanding opportunities for local entrepreneurs to grow the value-added product market while addressing important needs in the area of human nutrition.

Through the centers, small-scale entrepreneurs – most often women - pay a small fee to utilize mechanized food processing equipment in order to test and develop high-quality sorghum and millet products for commercial sale. The entrepreneurs use inexpensive, locally-appropriate food processing technologies and also have access to business and technical support and training. Additionally, they are educated on the importance of purchasing high-quality grain for their businesses and are encouraged to obtain it from local farmers.

As a part of this project, researchers and entrepreneurs will also be experimenting with the development of new, nutrient-fortified food products, including infant food products and thin porridge flours. The fortification will be sourced from nutrient-dense plant materials found locally, such as amaranth, baobab, pumpkin leaf, wild jute, cowpea leaves, spider flower, mango and carrots.

Hamaker's project is based on the technology incubation center model that was first created under the leadership of the Sorghum and Millet Innovation Lab's predecessor, the INTSORMIL CRSP. First launched in Niger, and later expanded to Mali, Senegal and even Kenya, this model has a strong track record of successes in growing local markets and business opportunities in both rural and urban settings.

The centers have a history of helping to carve out local and regional markets for traditional food products like couscous and boulet, which are popular in West African countries but typically have to be imported from North Africa or Europe. Through sustained USAID investment, the Sorghum and Millet Innovation Lab will build on this legacy with an increased focus on fortified sorghum and millet products that can position smallholders to earn more income supplying nutritious foods. To learn more about the Sorghum and Millet Innovation Lab and the future of the technology incubation centers, go to [www.k-state.edu/smil/](http://www.k-state.edu/smil/).





*A processor in Niger dries her product on a rooftop in preparation for packaging and sale.*

## **STORY #2**

### **The search for sorghum stress resistance and novel genes**

*Three researchers come together in a coordinated effort to find new sources of resistance in sorghum*

For the hundreds of millions of people around the world that depend on sorghum as the foundation of their livelihood, the threat of losing a season's crop is alarming. In Ethiopia, sorghum serves as a source of food, livestock feed and building materials, making common environmental stressors such as drought, disease and pests potentially devastating to entire families and villages. In an effort to diminish these risks faced by so many Ethiopian farmers, three research teams have combined efforts in a coordinated hunt for new sources of stress resistance in sorghum.

The initiative, led by Drs. Gebisa Ejeta and Tesfaye Mengiste of Purdue University and Dr. Tesfaye Tesso of Kansas State University, is part of a broader strategy under the Feed the Future Innovation Lab for Collaborative Research in Sorghum and Millet. The Lab's research priorities are aimed at improving the adaptation and resilience of sorghum and pearl millet to the semi-arid climates of East and West Africa, and its support of the three scientists is an important step towards achieving that.

One of the researchers' first accomplishments was to plant 2,500 different sorghum lines in numerous test nurseries across Ethiopia. Plantings were completed in the summer of 2014, and the nurseries represent the broad range of climatic and environmental stressors present in the country. Very likely the largest screening of its kind in Ethiopia, the planted lines include local landraces, improved open-pollinated varieties and hybrids. Ethiopia is generally considered as the genetic origin for sorghum, and the countless landraces bring promise of access to a great diversity of genetic material. Many of the lines being evaluated are not a part of the U.S. germplasm collection, making the initiative a unique opportunity to comprehensively explore the Ethiopian sorghum germplasm and identify areas of promise for the development of new stress-resistant varieties.

In order to gain access to the extensive breadth of land races and successfully plant test plots in so many regions, the research team relied on linkages with the Ethiopian Institute of Biological Diversity and the Ethiopian Institute for Agricultural Research, as well as regional programs and universities. From the broad collection of germplasm planted, the researchers have been able to begin screening the varieties for a diverse range of desirable characteristics, including grain quality, drought resistance, disease resistance and *Striga*\* resistance. These screenings will soon be paired with genotyping that will compare each plant's expressed characteristics with its DNA to locate specific genes that are linked resistance or grain quality. By doing this, the researchers will be able to identify the lines that carry the greatest potential for future breeding activities. This will give Ethiopian and international breeders alike the tools they need to create better, more resilient sorghum varieties, and in turn result in greater food security and income-generating opportunities for countless sorghum farmers around the world.

*\*Striga is a parasitic plant that attacks sorghum, often resulting in high losses.*





*A team of sorghum researchers at a field visit at the Werer Research Station in central Ethiopia.*

## **STORY #3**

### **Laying a collaborative foundation for a sustainable future**

*New Innovation Lab takes multi-actor approach to ensure relevant solutions*

Tackling issues that include global hunger and food security is no small feat, and when the new Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet was charged with doing just that, it knew that the way in which the foundation was laid was imperative to its success in addressing such important challenges.

Led by a keen understanding of the need for a multi-actor approach when confronted with complex issues, the Sorghum and Millet Innovation Lab began building its collaborative method even before its formation was made official. In the fall of 2013, future Lab director Tim Dalton and assistant director Nat Bascom traveled to the proposed focus countries to facilitate priority-setting meetings. In these meetings, the pair gathered key players in sorghum and millet research, NGOs, ministries of agriculture and other relevant development actors to gain a clear understanding of the greatest areas of need – and potential – in sorghum and millet. The resulting conclusions served as the basis of the Lab's vision and road map for the future.

That same spirit of collaboration carried through in the Lab's call for research project proposals, with priority being placed on those that demonstrated a strong understanding of the key actors and partners within the sorghum and millet research communities. The final ten-project research portfolio selected by the Lab is focused on three African countries – Ethiopia, Niger and Senegal – but directly incorporates actors from 36 different institutions in seven different countries, and which range from farmer organizations to universities to research stations.

When the research teams were called together in the spring of 2014 for project inception meetings, the Lab management team used the opportunity to help forge links within the sorghum community itself. Government officials and development actors were invited to take part in discussions and the exchange of ideas. Regional actors from outside of the focus countries were asked to offer input and identify potential areas of collaboration in related projects. Research teams presented their project objectives to fellow scientists in order to pave the way for additional opportunities for cooperation and between the Lab-funded projects.

With the multi-actor, collaborative approach serving as the basis for all Sorghum and Millet Innovation Lab activities, the foundation has been laid for a relevant, impactful research program. Regular reassessment of activities and efforts to draw in additional players will help to ensure the best sustainable, relevant solutions to some of the world's most complex problems in some of the world's harshest agricultural areas.



*Research teams use working sessions to tighten objectives and finalize work plans during inception meetings in Adama, Ethiopia.*