



Collaborative Research
on Sorghum and Millet

2015 ACTIVITIES & IMPACTS



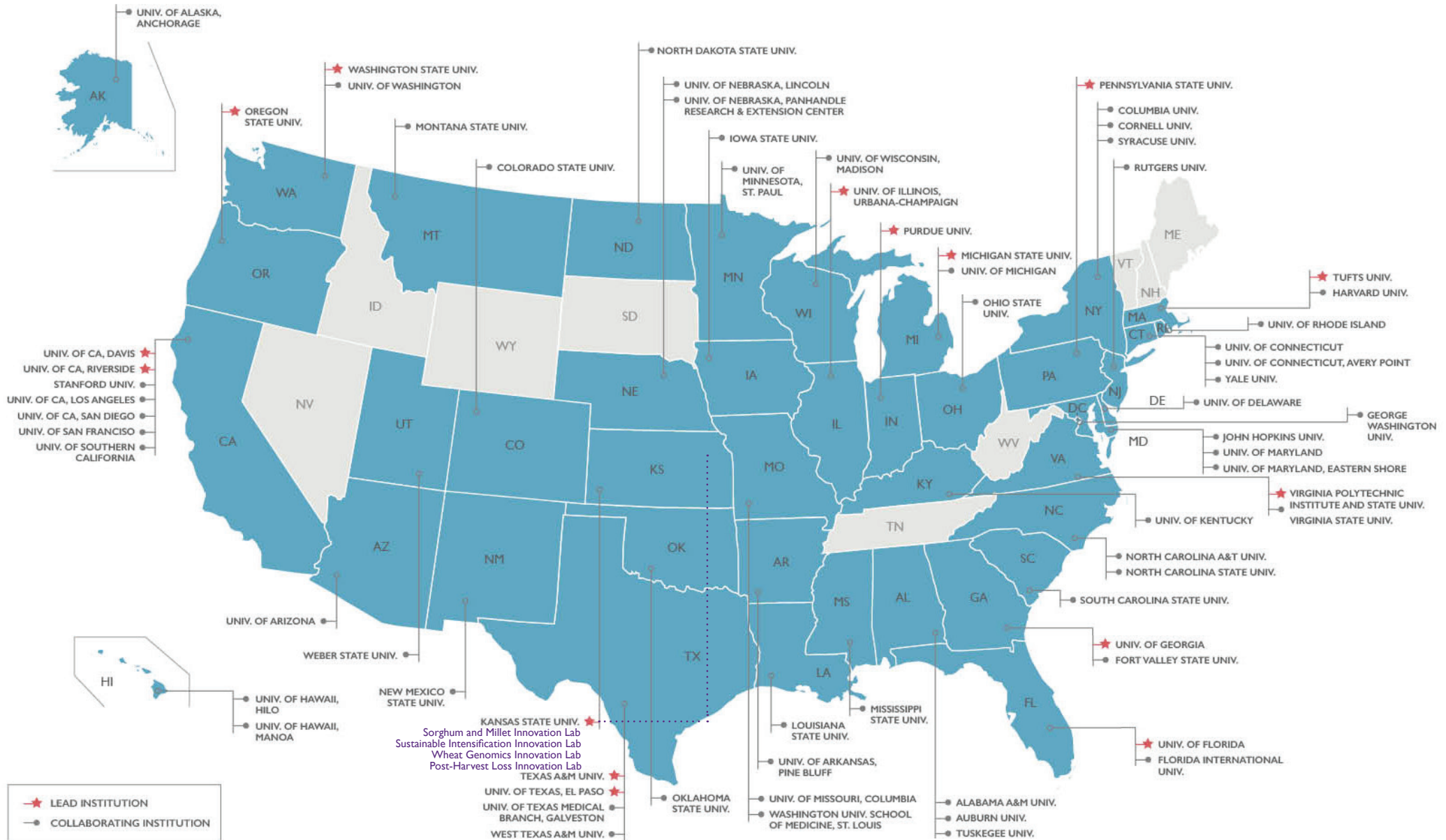
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The U.S. Government's Global Hunger & Food Security Initiative

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The Feed the Future initiative partners with universities throughout the world. This is a sampling of university partners located in the United States. For more information and updates, visit www.feedthefuture.gov or follow on Twitter @FeedtheFuture.

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INNOVATING SCIENCE
TO BUILD THE CROPS OF THE FUTURE

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DRIVING INNOVATION

Sorghum and millet are staple crops for hundreds of millions of people around the world, providing food, animal feed and building materials to some of the most food-insecure populations on Earth. The Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet is a global hub of cutting-edge research focused on increasing the resiliency of small-scale sorghum and millet producers in the face of climate change and creating entrepreneurial opportunities to reduce poverty and hunger.

Because of their resiliency, sorghum and millet are grown commonly in arid climates, including the West African Sahel and the Horn of Africa. Those regions are where the Lab focuses its work, with activities centered primarily in Senegal, Niger, Mali, Burkina Faso and Ethiopia. Research collaborators include universities and research centers from the focus countries, as well as partners in South Africa, Germany, France and the United States.

The Lab's portfolio is aimed at the development of new technologies, management practices and food and feed products to help serve some of the world's most vulnerable populations. It enlists more than a hundred researchers, post-doctoral associates, graduate students and project management team members to create a robust and impactful program to drive innovation in addressing food insecurity.



OUR TEAM

The Lab management entity works hand-in-hand with the external advisory board to ensure a high-quality and relevant research program.

THE STAFF



Timothy Dalton
Director



Nathaneal Bascom
Assistant Director



Kira Everhart-Valentin
Program Coordinator



Kristen Sanborn
Business Financial Specialist



Shelby Mettlen
Communications Assistant



Shawn Wittkopf
Database
Development Intern

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Ethiopian Academy of Sciences



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University of Hohenheim &
McKnight Foundation



Tim Lust
National Sorghum Producers



Peter Matlon
Cornell University



Barbara Stoecker
Oklahoma State University

OUR TEAM

The Lab research team includes co-investigators from 33 public and private institutions across nine different countries.

THE RESEARCHERS



ETHIOPIA RESEARCH TEAM

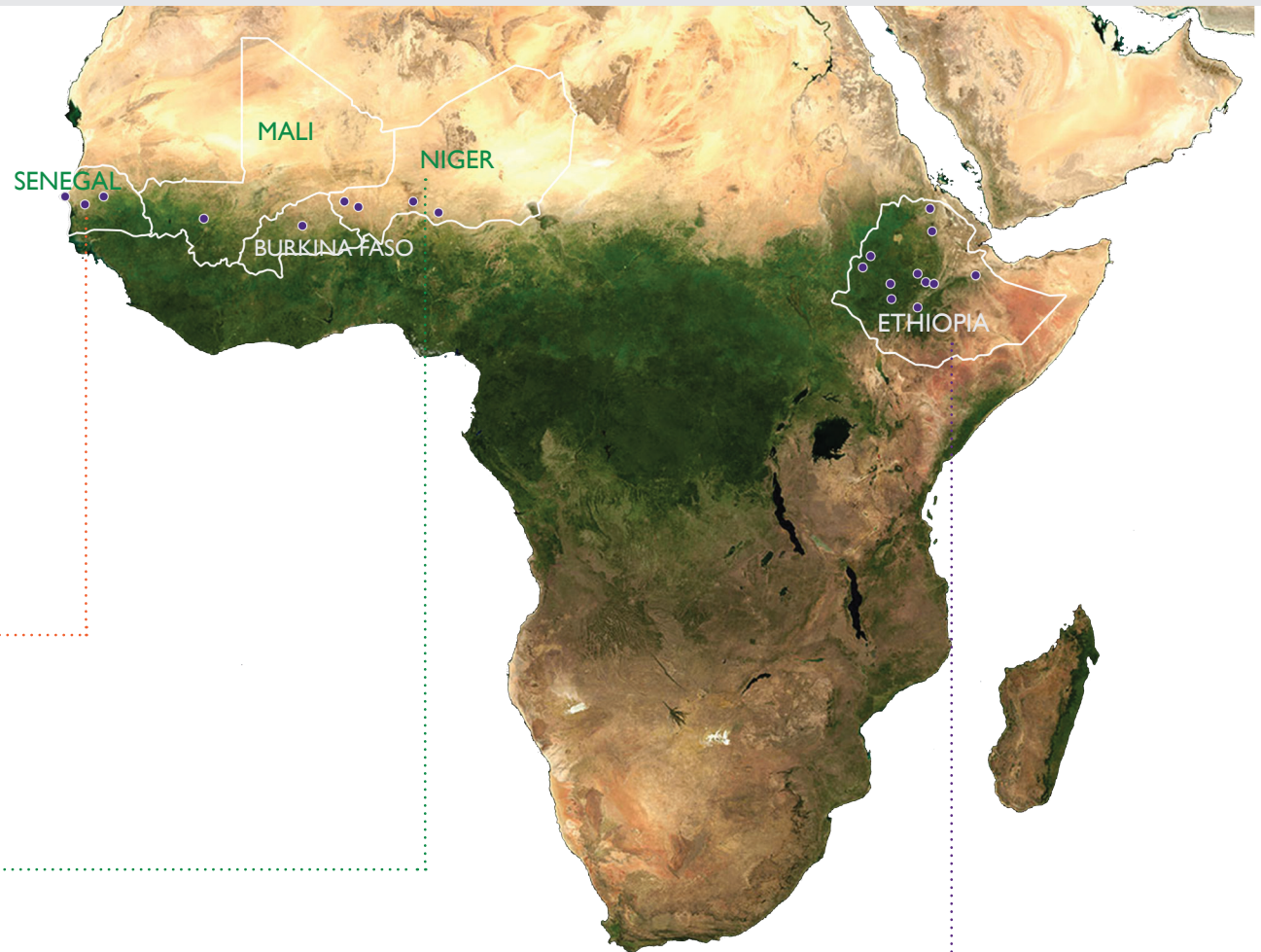


WEST AFRICA RESEARCH TEAM

WHERE WE WORK

The Lab's primary geographical focus is across Africa's Sahel region, where sorghum and millet are staple crops that play a key role in food security.

The Sorghum and Millet Innovation Lab continues to work primarily in its original focus countries of Ethiopia, Senegal and Niger, but has also recently added Mali and Burkina Faso to that list. The addition of these two West African countries will contribute to the cohesion of the Lab's regional research strategy.



COUNTRY COORDINATORS

Ndiaga Cisse

Senegal



Moustapha Moussa

Niger



Getachew Ayana

Ethiopia

OUR COLLABORATORS

One of the Lab's greatest strengths lies in its many collaborators and partners from around the world.



Federation de Unions de Producteurs de Maradi
- FUMA GASKIYA (Farmer organization)

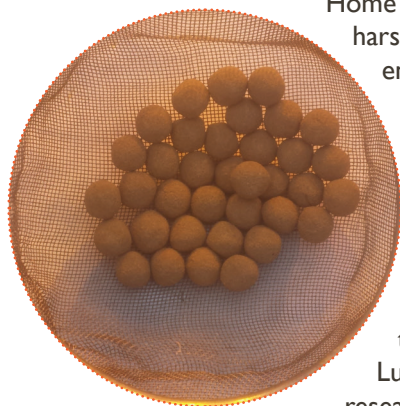
Holleta Biotechnology
Center

Sirinka Agricultural
Research Center

LSDS (Farmer
organization)

SMALL SEED, BIG IMPACT

Innovative seedball technology may offer sustainability and greater yields to sorghum farmers



Home to one of the harshest cropping environments in the world, the Sahel region of Africa hosts poor, sandy soils, low and erratic rainfall, and excessive soil surface temperatures.

Ludger Herrmann, a researcher from the University of Hohenheim

whose project is funded by the Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet, is working to improve seeding success rates and combat these harsh conditions with a tiny capsule that may revolutionize Sahelian cropping systems: the seedball.

The seedball technology, which is part of a long-term collaborative research effort with farmer organizations in Niger and Senegal, is small enough to fit in the palm of your hand, but holds the power to change the lives of farmers in the Sahel.

According to Herrmann, the greatest challenge faced by the research team is how to improve major staple cropping in the region in order to increase food security and resilience. Sahelian farmers often have limited space for cropping, very low incomes and restricted access to inputs such as fertilizer and pesticides. This combination of limitations makes it difficult for farmers to subsist on their cropping

operations, and nearly impossible to sell their crops for income.

“Millet stand establishment is often a problem with emergence followed by intermittent drought so seedlings die, which forces the farmer to sow again, and then even a third time,” said Timothy J. Dalton, Lab Director.

By creating microenvironments that can capture moisture and make nutrients more readily available, the seedball has the potential to break this cycle.

Herrmann and his team invested in “local fertilizer” to create the seedballs, using a combination of products that are easily accessible to subsistence farmers in the Sahel. Wood ash, a resource available in every household, provides water soluble phosphate while urine is used to close the nitrogen gap. Potassium from wood ash also allows for stomal closure in the emerging plant, which allows for higher water use efficiency. Because of this, Herrmann said it is expected that plants emerging from seedballs have a higher drought tolerance and can survive longer dry spells than plants that are dry scattered as seeds. If so, he said, seedballs will increase labor efficiency and reduce seed demand.

“These fields often fail to produce yield due to the fact that plants emerge after little rain that is followed by drought,” he said. “The nutrient formulation of the seedballs should support early plant growth, root growth in particular, so that seedlings are able to exploit a larger soil volume.”

While physical optimization of seedballs may be a challenge, Herrmann said the long-term goal is to

define additives so seedball seeds germinate with a defined minimum amount of rainfall.

“We believe that seedballs can improve the local millet and sorghum cropping systems by reducing seed expenditures, increasing seedling survival, enhancing nutrient and water use, and finally by reducing cropping risk, increasing yield and thus income and resilience,” Herrmann said.

The key will be to show that the seedballs are an effective measure to enhance seeding survival and growth in the very early growth stages. Final yield is determined by the length of the growing season, and each day that a crop emerges earlier will increase yield, Herrmann explained.

The seedball is a potential powerhouse in its miniscule packaging. It is a low-cost technology with low application risk for farmers, particularly women who are often even more limited in their access to inputs. With its low investment requirements, researchers hope that the seedball technology will continue to offer exciting promise in semi-arid landscapes with sandy soils like those found throughout the Sahel.



Photo credits: Charles Ikenna Nwankwo and Ludger Herrmann

MAKING DISCOVERIES

The Sorghum and Millet Innovation Lab's portfolio is leading innovative research focused on improving the adaptation and resilience of sorghum and millet to the semi-arid climates of East and West Africa, and in doing so, contributes to food security, household resilience and private sector growth.

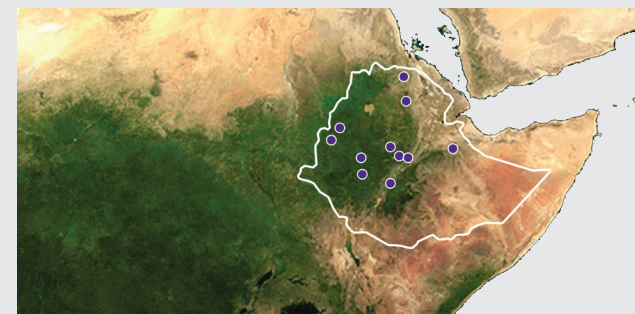
As of last year, approximately 57 percent of project funding was invested into genetic enhancement of sorghum and millet, 20 percent in production systems management and 23 percent in added-value product development and markets. Of the funds invested in research, 42 percent of the total was invested in projects targeting Ethiopia and 58 percent in projects in Mali, Burkina Faso, Senegal and Niger.

In tackling issues from all along the value chain, the Lab's objective is to discover applicable, practical solutions to address the many challenges faced by millions worldwide due to food insecurity and poverty.



OUR PROGRESS

Ethiopia



Developing superior functionality in sorghum for food applications to promote sorghum value chain in Ethiopia

PROJECT PI Joseph Awika

LEAD INSTITUTION Texas A&M University

FOCUS COUNTRY Ethiopia

U.S. COLLABORATING INSTITUTION Texas A&M University

INTERNATIONAL COLLABORATING INSTITUTIONS

Hawassa University, University of Pretoria

PROJECT OBJECTIVE:

To improve the functionality of sorghum, develop new food products and accompanying food processing techniques, through the adaptation of waxy and heterowaxy (WX/HX) sorghum hybrids with high lysine, high protein-digestibility (HPD) traits in Ethiopia.

2015 PROGRESS:

- WX/HX and high-lysine, HPD lines useful for human food products were grown in locations in Texas and Ethiopia and it was found high environmental interaction with genetic background affected physicochemical properties and quality traits.
- Food processing experiments were initiated at Hawassa University and a substitution of 65 percent of sorghum for tef in injera production was achieved with similar quality results.
- Protocols for hedonic evaluation of injera were developed including sensory attributes and descriptive terminologies and were later tested on a human panelists at Hawassa University.



Genetic enhancement of sorghum to promote commercial seed supply and grain market development in Ethiopia

PROJECT PI Gebisa Ejeta

LEAD INSTITUTION Purdue University

FOCUS COUNTRY Ethiopia

U.S. COLLABORATING INSTITUTIONS Purdue University, Kansas State University

INTERNATIONAL COLLABORATING INSTITUTIONS

EIAR (Melkassa Research Center, Sirinka Research Center), Holleta Biotechnology Center, Tigray Regional Program, Oromia Regional Program, Haramaya University

PROJECT OBJECTIVE:

To develop drought and Striga-resistant varieties and hybrids through large-scale phenotyping of Ethiopian and novel germplasm that will then be used to strengthen the seed supply value chain for the development of an Ethiopian commercial seed sector.

2015 PROGRESS:

- A set of 762 experimental hybrids synthesized at Purdue University were introduced to Ethiopia to catalyze the emergence of a commercial sorghum seed industry.
- Twenty-nine stay-green hybrids (of 50 evaluated) were selected as promising in Mieso; of the 114 early hybrids evaluated at Chiro and Kobo for mid-season drought, 43 were selected as promising.
- Of 173 seed parents and 267 pollinator parents introduced to Ethiopia, 62 seed parents and 120 R lines, respectively, were selected as promising for subsequent testcrossing to produce experimental hybrids.

OUR PROGRESS

Ethiopia



Genetic improvement of sorghum for resistance to fungal pathogens

PROJECT PI Tesfaye Mengiste

LEAD INSTITUTION Purdue University

FOCUS COUNTRY Ethiopia

U.S. COLLABORATING INSTITUTIONS Purdue University,

Kansas State University

INTERNATIONAL COLLABORATING INSTITUTIONS

ELAR (Asosa Research Center, Pawe Research Center, Bako Research Center), Holleta Biotechnology Center

PROJECT OBJECTIVE:

To utilize local landraces to create high-yielding, disease-resistant sorghum varieties through the application of genomics while studying the prevalence of fungal species causing grain mold and anthracnose.

2015 PROGRESS:

- Diverse sorghum lines (over 2,000) from the Ethiopian germplasm collection were planted at Mieso, Arsinegelie, Haramaya, Kobo, Pawe, and Bako research centers under the joint germplasm evaluation activity and scored for disease resistance.
- Ninety-five improved sorghum lines from Purdue University and additional lines from Melkassa with some history of grain mold resistance were grown in Assosa, Bako, Jimma and Pawe and evaluated for disease resistance.
- Collection of *Colletotrichum sublineolum* strains from representative sites in Ethiopia was conducted and the fungal strains and their characterization was initiated. An APHIS permit was acquired for importation to the U.S. for whole genome sequencing and characterization.
- Recombinant inbred populations derived by crossing resistant and susceptible accessions, followed by many generations of selfing, were used for mapping anthracnose-resistant loci.



Improved crop genetics and processing methods for increased productivity and nutrition for smallholder sorghum producers in Ethiopia

PROJECT PI Tesfaye Tesso

LEAD INSTITUTION Kansas State University

FOCUS COUNTRY Ethiopia

U.S. COLLABORATING INSTITUTIONS Kansas State University, USDA-ARS, Purdue University, KSU - Hays Research Station

INTERNATIONAL COLLABORATING INSTITUTIONS

ELAR (Melkassa Research Center, Sirinka Research Center, Pawe Research Center), Tigray Agricultural Research Institute, Haramaya University

PROJECT OBJECTIVE:

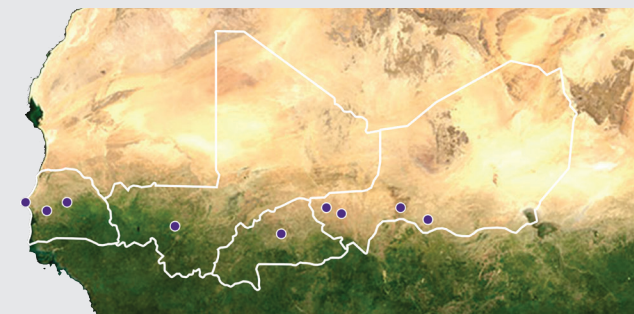
To develop high-yielding, locally-adapted sorghum varieties and hybrids with highly-digestible protein that are rich in essential micronutrients, suitable for local processing methods and diverse production systems.

2015 PROGRESS:

- Building upon the sorghum population that was developed in 2014, 2,100 entries were planted at several locations in Ethiopia. Agronomic, nutritional and disease resistance data are being collected by collaborators at respective locations.
- Approximately 2,100 hybrids were created from the population and the F1 progenies are growing at the Melkassa Research Center to determine their fertility status.
- A large breeding population with improved quality attributes (primarily protein digestibility) has been developed between renowned Ethiopian high-lysine sorghum landraces, ISI 1178 and ISI 1267, and local improved varieties adapted to various regions of the country.

OUR PROGRESS

West Africa



Improving sorghum adaptation in West Africa with genomics-enabled breeding

PROJECT PI Geoffrey Morris

LEAD INSTITUTION Kansas State University

FOCUS COUNTRIES Senegal, Niger

U.S. COLLABORATING INSTITUTION Kansas State University

INTERNATIONAL COLLABORATING INSTITUTIONS

ISRA/CERAAS/CNRA, ICRISAT, INRAN, LSDS, HALAL (farmer organizations)

PROJECT OBJECTIVES:

To accelerate marker-assisted breeding in West Africa through the construction of a genomics-enabled breeding platform in order to develop new locally-preferred sorghum varieties with improved adaptive traits.

2015 PROGRESS:

- Seedling growth and DNA extraction has taken place on over 800 entries from the West African Sorghum Association Panel consisting of entries from Senegal, Mali, Niger, and Togo.
- Library preparation, Illumina sequencing, SNP discovery and typing has taken place through Genotyping-by-Sequencing and the first country and program set of markers are being identified.
- Irrigation facilities at Tillaberi, Niger have been installed and the first testing of managed drought stress phenotyping has been carried out.
- Local collections of Striga seed has been made and the first testing of the enhanced Striga field conducted with 15 selected lines.



Development of biotic stress-resistant sorghum cultivars for Niger and Senegal

PROJECT PI Bonnie Pendleton

LEAD INSTITUTION West Texas A&M University

FOCUS COUNTRIES Senegal, Niger

U.S. COLLABORATING INSTITUTIONS West Texas A&M

University, Texas A&M AgriLife Research

INTERNATIONAL COLLABORATING INSTITUTIONS

ISRA, CNRA, CERAAS, INRAN

PROJECT OBJECTIVES:

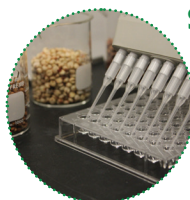
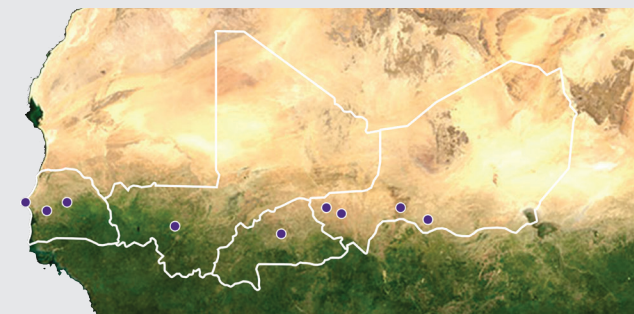
To develop insect-resistant sorghum varieties and improved environmentally-friendly storage methods through an interdisciplinary research approach.

2015 PROGRESS:

- Nurseries were established in Senegal and Niger to evaluate resistance against biotic and abiotic stresses such as the sorghum midge, grain mold, weathering, and drought tolerance.
- A total of 103 sorghum lines were provided to Senegal collaborators for local increase to provide grain for research on insect pests of stored grain.
- Farmers were taught to identify insect pests of stored grain.
- Scanning electron microscopy procedures were simplified and refined to better correlate resistance of stored sorghum grain to maize weevils.

OUR PROGRESS

West Africa



Sorghum trait development pipeline for improved food and feed value

PROJECT PI Mitchell Tuinstra

LEAD INSTITUTION Purdue University

FOCUS COUNTRIES Senegal, Niger

U.S. COLLABORATING INSTITUTION Purdue University

INTERNATIONAL COLLABORATING INSTITUTIONS

ITA, CERAAS, ISRA, CNRA, INRAN

PROJECT OBJECTIVES:

To leverage new genetic technologies including the sorghum genome sequence and a proven population of sequence-indexed mutants to identify alleles that influence grain quality traits, which will then be incorporated into locally-adapted cultivars and hybrids.

2015 PROGRESS:

- Seeds for selected EMS lines and other genetic materials were sent to collaborators in West Africa for phenotype evaluation for protein digestibility (Senegal) and brown midrib forage (Niger) quality traits.
- High throughput analysis of a mutant population by forward and backward genetic strategies to identify mutations that change protein digestibility was conducted.
- Genetic crosses between mutants with highly-digestible protein and mutants with bmr traits have occurred with elite parent lines and varieties from West Africa.
- Breeding programs to introgress new food- and feed-value traits into West African sorghum varieties continues.



Biological control of the millet head miner in Niger and Senegal

PROJECT PI Malick Ba

LEAD INSTITUTION ICRISAT - Niger

FOCUS COUNTRIES Senegal, Niger

U.S. COLLABORATING INSTITUTIONS Virginia Tech University,

IPM Innovation Lab

INTERNATIONAL COLLABORATING INSTITUTIONS

ISRA, CERAAS, University Cheik Anta Diop de Dakar, University of Maradi, INRAN

PROJECT OBJECTIVES:

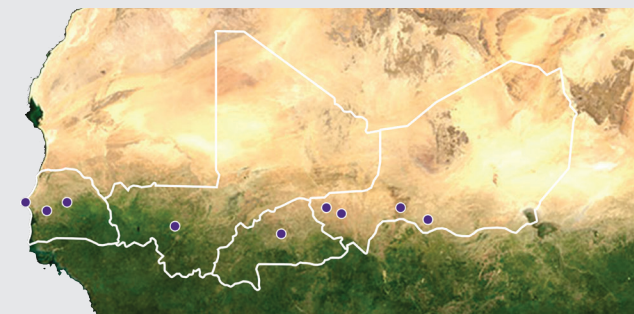
To test and fine tune the mass rearing and release techniques of millet head miner egg and larval parasitoids while establishing a cottage industry for production, distribution and management as an entrepreneurial opportunity for increased rural income.

2015 PROGRESS:

- Rearing and release of the *H. hebetor* parasitoid was refined through field experimentation in several sites and parasitism ranged from 15-50 percent in the Zinder district and from 35-67 percent in the Tera district.
- Focus group discussions with farmers in villages have established the “public good” nature of distributing the parasitoids.
- Important progress is being made to strengthen the biocontrol process by searching for egg parasitoids, *Trichogrammatidae armigera*, in addition to refining larval control processes. A total of 5,957 eggs of the MHM were collected in Western Niger in the districts of Tera, Dantchandou, Filingue and Say and monitored until emergence of parasitoids. Difficulties were encountered in rearing the egg parasitoids on factious hosts under controlled conditions.

OUR PROGRESS

West Africa



Optimization of seed ball technology for pearl millet, and agronomic and socio-economic evaluation in the context of smallholder farmers in Senegal and Niger

PROJECT PI Ludger Herrmann

LEAD INSTITUTION University of Hohenheim - Germany

FOCUS COUNTRIES Senegal, Niger,

INTERNATIONAL COLLABORATING INSTITUTIONS

INRAN, ISRA, FAPAL and Fuma Gaskiya (farmer organizations)

PROJECT OBJECTIVES:

To optimize an innovative pearl millet seed ball technology for improved plant establishment and evaluate its performance under Sahelian growing conditions while determining both the agronomic and socio-economic benefits to farmers.

2015 PROGRESS:

- Seedballs were physically optimized at an optimum diameter of 1.5-2.0 cm with random distribution of seeds.
- Chemical optimization was also successful with a basic composition as a gravimetric ratio is as follows: 80 parts sand, 50 parts loam, 25 parts water, and 3 parts wood ash or 1 part NPK fertilizer.
- In 2015, two identical on-station trials were successfully conducted by ISRA and INRAN in Bambey, Senegal and Maradi, Niger.
- Thirty on-farm trials were conducted in three villages of the Serkin Haoussa district. In Senegal, only one “central” trial site was chosen by the local farmers. Post-season assessment of the technology led to the result that most (>90%) farmers want to continue testing in the 2016 season.
- One survey in Senegal was conducted by a B.Sc student (Konni Biegert) from Hohenheim University. The B.Sc-thesis is available and detected no ex-ante reasons for non-adoption of the seedball technology.



Expanding markets for sorghum and millet farmers in West Africa through strengthening of entrepreneur processors and nutrition-based promotion of products

PROJECT PI Bruce Hamaker

LEAD INSTITUTION Purdue University

FOCUS COUNTRIES Senegal, Niger

U.S. COLLABORATING INSTITUTION Purdue University

INTERNATIONAL COLLABORATING INSTITUTIONS

ISRA, CNRA, ITA, INRAN

PROJECT OBJECTIVES:

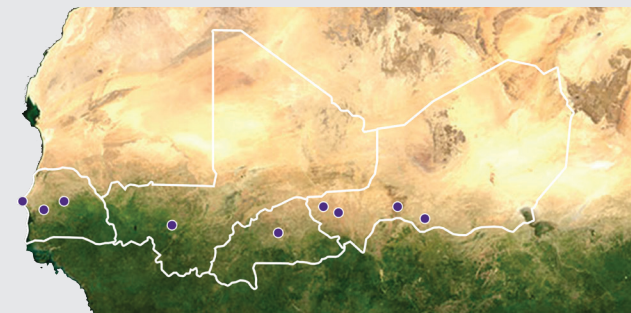
To work with entrepreneur food processors through local incubation centers to develop new value-added extruded foods, promote nutrient-fortified processed sorghum and millet products, and increase market demand in urban areas.

2015 PROGRESS:

- Several food formulas made with millet and sorghum with local fruits such as baobab fruit flour, cowpea, and peanut were developed.
- Sensorial analyses have been run for each new product to assess their potential in the urban and rural markets.
- Local purported nutrient-rich plant materials, such as baobab, bali, bambara nut, lam, cowpea, oule, gum arabic, nere, palm nut, roselle and tiger nut were collected in Niger and Senegal, and analyzed for pro-vitamin A carotenoids and minerals.
- An extruder for developing and processing nutrient-enriched instant flours was purchased for installation in Niger, as well as a flour sieving machine and other minor processing accessories.
- A contracting partnership was initiated between urban processors operating in Niamey and local grain growers from two farmer organizations: Moribeen/Western Niger (Tillabery and Dosso) and Fuma Gaskiya/Eastern Niger (Maradi).

OUR NEWEST PROJECT

West Africa



Development of dual-purpose pearl millet varieties for the benefit of farmers and agro-pastoralists in the Sahelian and Sudanian zones of West Africa



This project aims to tackle the challenges of both human and animal malnutrition by setting the foundation and developing a strategy for farmer-participatory breeding of highly

nutritious, dual-purpose pearl millet varieties in the target countries Senegal, Mali, Burkina Faso and Niger. The development and cultivation of dual-purpose pearl millet varieties with enhanced grain nutritional quality and stover digestibility is expected to contribute to better crop-livestock integration and improved incomes and even nutritional security of smallholder farming families.

The project will gather and characterize at least 100 accessions of germplasm from the countries involved and other millet breeding programs to determine the genetic diversity for stover quality and digestibility traits, grain

mineral content, and grain and stover yield performance. It will also assess relationships between stover nutritional quality and digestibility and agro-morphological traits, as well as grain micronutrient contents, to understand potential trade-offs in selection of nutritious dual-purpose pearl millet cultivars, validate superior germplasm accessions in a participatory manner with women and men farmers in large-scale on-farm trials in the target regions, and identify farmer-preferred accessions for use in future dual-purpose pearl millet breeding programs.

The genetic material will be multiplied to make seed available for farm multi-location trials and complementary grain chemical analyses. At least superior dual-purpose varieties with superior yield and good quality for grain and stover/fodder will finally be selected by country and a seed multiplication system involving breeder-foundation and certified seed will be put in place to make seed available to the users (farmers, agopastoralists, etc.). Capacity building will include stakeholder training on quality seed production techniques, identification of diseases, insects, parasitic weeds and other biotic millet production constraints.

Roger Zangré



Principal Investigator

LEAD INSTITUTION

Institut de l'Environnement et de
Recherches Agricoles (INERA)

AWARD AMOUNT

\$495,000

FOCUS COUNTRIES

Senegal, Niger, Burkina Faso, Mali

U.S. COLLABORATING INSTITUTION

Kansas State University

INTERNATIONAL COLLABORATING INSTITUTIONS


INERA, IER, CERAAS/ISRA,
INRAN, ICRISAT

TECHNOLOGY & MANAGEMENT

Technologies and practices under development

The Sorghum and Millet Innovation Lab has a diversified research program that focuses on seed technology development, crop and resource management interventions and food product development. Concurrent with this strategy is the diversified technology development pipeline with variety, hybrid and seeds targeted at the long-term, with near to intermediate term delivery of crop and resource management interventions, and a more continuous delivery of food products.

TECHNOLOGIES UNDER RESEARCH: STAGES OF DEVELOPMENT

<p><u>Genetic Enhancement</u></p> <ul style="list-style-type: none">• Sorghum germplasm/variety development for food quality• Parental materials for disease resistance• Experimental hybrids for commercial sorghum seed industry• Genomics-enabled breeding platform• Locally-preferred sorghum varieties with improved adaptive traits• Insect-resistant sorghum cultivars• Food quality traits in sorghum• Forage digestibility traits in sorghum• Dual-purpose pearl millet varieties <p><u>Production Systems Management</u></p> <ul style="list-style-type: none">• Seed balls targeted to Sahelian pearl millet based farming systems	<p><u>Production Systems Management</u></p> <ul style="list-style-type: none">• Direct release of <i>Habrobracon hebetor</i> adults for controlling the millet head miner <p><u>Added-value products and markets</u></p> <ul style="list-style-type: none">• Improved endosperm sorghum for protein quality and processing functionality• Extruded sorghum- and millet-based food products	<p><u>Production Systems Management</u></p> <ul style="list-style-type: none">• Mass rearing of parasitoids for biological control (expected for 2016) 
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Phase I
Under research

Phase II
Under field testing

Phase III
Made available for transfer

REVOLUTIONIZING SORGHUM

Scientists from Purdue, K-State team up to revolutionize sorghum stress resistance



Thousands of acres of sorghum are planted by farmers each year in Africa's semi-arid East and West regions. Thanks to the harsh climate, only a fraction of the planted crop is harvested each year, often leaving small

Ethiopian farmers with little food, fewer resources and minimal income. With the help of the Sorghum and Millet Innovation Lab, three research teams are working to improve the adaptation and resilience to help farmers manage risk in Africa's unfavorable growing conditions. Researchers Gebisa Ejeta and Tesfaye Mengiste of Purdue University and Tesfaye Tesso of Kansas State University have teamed up to head the initiative.

In 2014, the three teams planted over 2,000 different sorghum lines in test nurseries across Ethiopia. Perhaps the largest screening of sorghum resistance in Ethiopia, the test plots represent the broad range of climatic and environmental conditions present in the target area. Considered the genetic origin for sorghum, Ethiopia's numerous landraces offer access to a diverse bank of genetic material. Because many of the lines being evaluated as part of the teams' research are not part of the U.S. germplasm collection, the initiative offers an exclusive opportunity to explore Ethiopian

sorghum germplasm and identify areas of growth and innovation for new stress-resistant varieties.

Researcher and associate professor of sorghum breeding and genetics at Kansas State University Tesfaye Tesso, said the ongoing research between three of the breeding and genetics-based projects in Ethiopia are aimed at enhancing productivity through deploying high-yielding drought tolerant hybrids, increasing resistance to leaf and panicle diseases and enhancing nutritional value of the crop with emphasis on improving protein availability.

"Our projects attempt to address these key components," Tesso said. "Any breakthrough in these efforts will have monumental effects on the lives of farmers who depend on this crop both in terms of enhancing productivity and income and in reducing protein malnutrition and building a healthy society."

The teams rely on partnerships with the Ethiopian Institute of Biological Diversity and the Ethiopian Institute for Agricultural Research (EIAR), along with regional programs and universities to gain access to the many landraces the region has to offer. Screening of planted germplasm has begun for characteristics include grain quality, drought resistance, disease resistance and Striga resistance. These screenings will be followed by genotyping to compare each plant's expressed characteristics with its DNA to locate specific genes that are linked to favorable traits in resistance or grain quality.

Ejeta, Mengiste and Tesso are paving the way for sorghum breeders across the globe as they provide the tools to create more resilient sorghum varieties. These new lines will provide sorghum farmers in

Ethiopia and all over the world with greater food security, greater income and greater stability. The improvement in protein availability in grain sorghum can have significant impacts on the sorghum industry globally, Tesso said.

"It can increase feed value where the crop is primarily used as animal feed and, through reducing protein malnutrition it can also significantly contribute to improved health of communities where sorghum serves as a staple," he said.

One of the components of the three projects focuses on unraveling the Ethiopian sorghum genetic diversity and eventually mining alleles associated with improved traits, Tesso explained.

"We have assembled about 2,000 sorghum germplasm accessions and they are being characterized for various traits," he said. "We also plan on genotyping the entire set of accessions and, through the use of bioinformatics tools, link genetic variants to the many traits being characterized. Given the richness in genetic diversity among the accessions, this effort may lead to major discoveries on several traits and the results have the potential to go beyond Ethiopia and positively impact the global sorghum industry."



IMPACTING LIVES

Created under the Feed the Future initiative, the Sorghum and Millet Innovation Lab is part of a broader network of Innovation Labs across the U.S. charged with the primary objectives of reducing global hunger and improving food security. Based at universities and research centers, these Labs use research, education and outreach to advance solutions to hunger, poverty and under nutrition in low-income countries.

In its second full year of project implementation, the Sorghum and Millet Innovation Lab has seen its research activities quickly begin to demonstrate the first steps towards essential, lasting impacts that serve as the ultimate goal driving the Lab's work. Through developments in sorghum and millet breeding and genetics, scientific advances in production and the enhancement of entrepreneurial opportunities along the value chains, the Lab is innovating science to make sorghum and millet the crops of the future.

With each research discovery, the Lab is also making positive contributions in the areas of human and institutional capacity through short-term and long-term trainings, gender sensitive agriculture, and environment compliance and safety. It is opening the doors to private sector linkages and exploring ways to tie current Lab research with domestic agricultural needs.



INVESTING IN THE FUTURE

Short-term and long-term training

Human and Institutional Capacity Development (HICD) continues to be a cornerstone of the Lab's program, and 2015 saw a number of exciting developments in this area. In addition to a total number of short-term trainees that significantly exceeded expectations, the Lab funded (either partially or in-full) 23 long-term training programs at institutions around the world.

SHORT-TERM TRAINING

TOTAL TRAININGS 46

TOTAL TRAINED 2358



LONG-TERM TRAINING

TOTAL TRAINED 23



TRAINING LOCATION



BACHELORS | **MASTERS** 6 | **PH.D.** 15 | **POST-DOC** 1

WHERE'S HOME?

NIGER	5	NIGERIA	2
ETHIOPIA	5	TOGO	1
SENEGAL	4	COTE d'IVOIRE	1
BURKINA FASO	2	U.S.	3

INVESTING IN THE FUTURE

Gender and environment



Gender Integration

Empowering women

Women are essential players in African agriculture with key roles in all areas from field work and planting all the way to threshing and food preparation. Yet, they often face the greatest constraints.

The Sorghum and Millet Innovation Lab is working actively to address these constraints through a three-tiered approach that includes addressing both more specific project-level opportunities, as well as broader opportunities at the program level. These include:

- **Gender integration action** plans developed at the project level to drive practical, obtainable steps that include human capacity activities, feedback session design and end-user preferences.
- **Gender and sorghum production study** as a country-specific exercise aimed at capacity building in the area of women in science as well as gathering gender-disaggregated data on sorghum production practices and uses in the major sorghum-producing regions of Ethiopia.
- **Efforts for increased participation of women in science** through the identification of female scientists whose research interests align with the Lab's portfolio and creating opportunities for involvement in project activities and long-term trainings.



Safety and Sustainability

Environmental compliance

The safety and sustainability of the Lab's research and training activities is of the highest priority, and the team's approach to strengthening environmental compliance across the program has been by addressing three key areas:

- **Orientation and training** in relation to environmental compliance was integrated into the annual planning meetings. Mission level environmental compliance officers and the USAID representatives were active participants.
- **Development of environmental planning** for the portfolio of research activities through work with principal investigators to seek feedback, reference documents, and input.
- **Development of an interactive space and process** through the creation of an Environmental Mitigation and Monitoring Plan module hosted on the existing online SMIL Resource & Reporting Hub for documentation, site visit reports and other monitoring activities that are key to ensuring environmental compliance across all projects.

CHANGING LIVES

Achieving success



Private Sector Linkages

Public-private partnerships

Development of corporate partnerships is a key method for incubating a new wave of feed and food products in order to stimulate demand. In 2015, the Lab assisted in catalyzing a partnership between a U.S.-based gluten-free/sorghum food product company and an Addis Ababa-based Ethiopian food product company with domestic market and injera export sales. The two companies have already initiated an exchange of product formulations and will continue into the future with the sharing of equipment ideas, planning for exchange visits, and the development of a stronger business/marketing plan.

Additionally, in order to stay knowledgeable of the various opportunities and challenges in the sorghum and millet industries, the Lab has been proactive in establishing strategic linkages in those areas. This has included serving as a main organizer of the 2015 Sorghum Improvement Conference of North America, and maintaining representation with key industry committees and events.



Bringing Science Home

Domestic impacts

While the research activities of the Sorghum and Millet Innovation Lab are focused on the challenges faced by African agriculture, many are the same hurdles being addressed by U.S. producers. That means that the Lab's efforts in tackling overseas problems has the potential of leading to a direct impact back at home.

One of the greatest areas of priority for the Lab is in genetic enhancement, with a particular focus on:

- Drought resistance
- Disease and pest resistance
- Varietal improvement

Advances in these areas will also mean improvements for U.S. agriculture as producers struggle with declining rainfall and groundwater, the pressure of new pests and diseases, and the need for better adapted varieties with increased yields. New genetic discoveries and access to new genetic material through international exchanges promise to contribute to crop improvement both abroad and at home.

BATTLING SORGHUM'S NEWEST ENEMY

Using 30 years of international science to fight a modern pest here at home



Recently, the sugarcane aphid has had sorghum farmers and breeders biting their nails as the tiny green pest bullies its way from Louisiana to Kansas, destroying sorghum fields along the way. The aphid was originally identified in Florida in 1977, but it wasn't a major sorghum pest in the U.S. until just two years ago. A known pest in some parts of Africa, the

sugarcane aphid got its first taste of American sorghum in 2013 and didn't look back.

After crossing into the Beaumont area of South Texas in late 2013, the aphid worked its way through the Rio Grande Valley in northern New Mexico and devastated sorghum. In fact, growers lost up to 50 percent of grain sorghum yield in infested fields during 2013. This represented a nearly \$8 million loss for growers in 2013 alone.

The sugarcane aphid has been progressively expanding its range ever since. It has proven to overwinter well in the sorghum-producing areas of the U.S., and is now identified as a pest across the country.

The most promising line of defense against the sugarcane aphid is in the development of resistant sorghum lines. However, breeding for resistance is a slow and painstaking process that can take years. Luckily for U.S. sorghum producers, breeders have been working on this problem for nearly 30 years through germplasm exchange and international collaboration, long before the aphid began wreaking havoc on American soil.

This isn't the first time long-term research investments have paid off for the sorghum industry. In the 1960s,

a similar pest called the greenbug aphid infested U.S. sorghum fields, leaving significant economic losses in their wake. However, thanks to the INTSORMIL* program and the exotic germplasm collection it funded, host plant resistance was developed, saving an estimated \$389 million in economic losses for the United States in 1989 alone (equivalent to nearly \$750 million in 2015 dollars). The investments made in Kansas, Texas and Nebraska on greenbug resistance is estimated to have generated a 48.2 percent rate of return on investment.

During this time, researchers conducted countless screenings of thousands of sorghum lines in search of resistance. While screening for greenbug resistance, they also identified some of the best lines for sugarcane aphid resistance, a quality that is now proving to be very important in addressing the needs of today's sorghum industry.

With the rise in prevalence of the sugarcane aphid, breeders have been looking harder at the sorghum lines they have developed and screened, and they have found those that show great promise for resistance. The origin of many of these lines is far from American soils.

"Because of the old INTSORMIL program, we've always had a lot of germplasm exchange," says Gary Peterson, a sorghum breeder at Texas A&M University. "Twenty years ago at Lubbock we obtained a number of introductions from Africa, and what I found in them was aphid resistance."

The main line of focus for sugarcane aphid resistance now, says, Peterson, is a line that was resistant to greenbug - a similar aphid species - and was being used as a pollinator in sorghum hybrids. That line, which originated from a previous sorghum conversion program from Ethiopia, has proven to be resistant to sugarcane aphid as well. Peterson and his team are hopeful that this resistance can be applied in the development of new sorghum varieties to combat the devastating pest.

Peterson is actively working with other researchers from

around the world to evaluate new lines and identify those that are the most promising. The hope, says Peterson, is to pull together all the resources possible to develop sorghum varieties that display resistance and make the economic devastation caused by the sugarcane aphid a thing of the past. Because of the years of investment by INTSORMIL and the focus it placed on international collaboration and information sharing, the development of those varieties may not be too far away.

"This research has been going on for years, even though the aphid just appeared here," he says. "This is something that was built upon research that was started 30 years ago."

No one knew when the sorghum breeding research first started that screenings for aphid resistance would be so needed three decades into the future. But the investments that were made and sustained now have important implications to sorghum growers and their bottom line. Likely, future investments in such research will yield similar benefits.

"There is so much diversity within sorghum that breeders don't work on just one trait," says Peterson. "When I plant a nursery, I look at adaptation, I look at grain weathering resistance, I look at foliar leaf quality, I look at anthracnose resistance, I do it all in the same plot. By simply taking advantage of the environment and the diversity we are able to develop populations that will deal with a lot. So when there is a new stress, there is a long-term program in existence to go back to - because in breeding research, it's not like you just turn a water faucet on and off. It's something that's a long-term deal."

**The International Sorghum and Millet Collaborative Research Support Program (INTSORMIL) is the predecessor to the Feed the Future Innovation Lab for Collaborative Research in Sorghum and Millet.*

Photo credit: Gary Peterson



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