



FEED THE FUTURE

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



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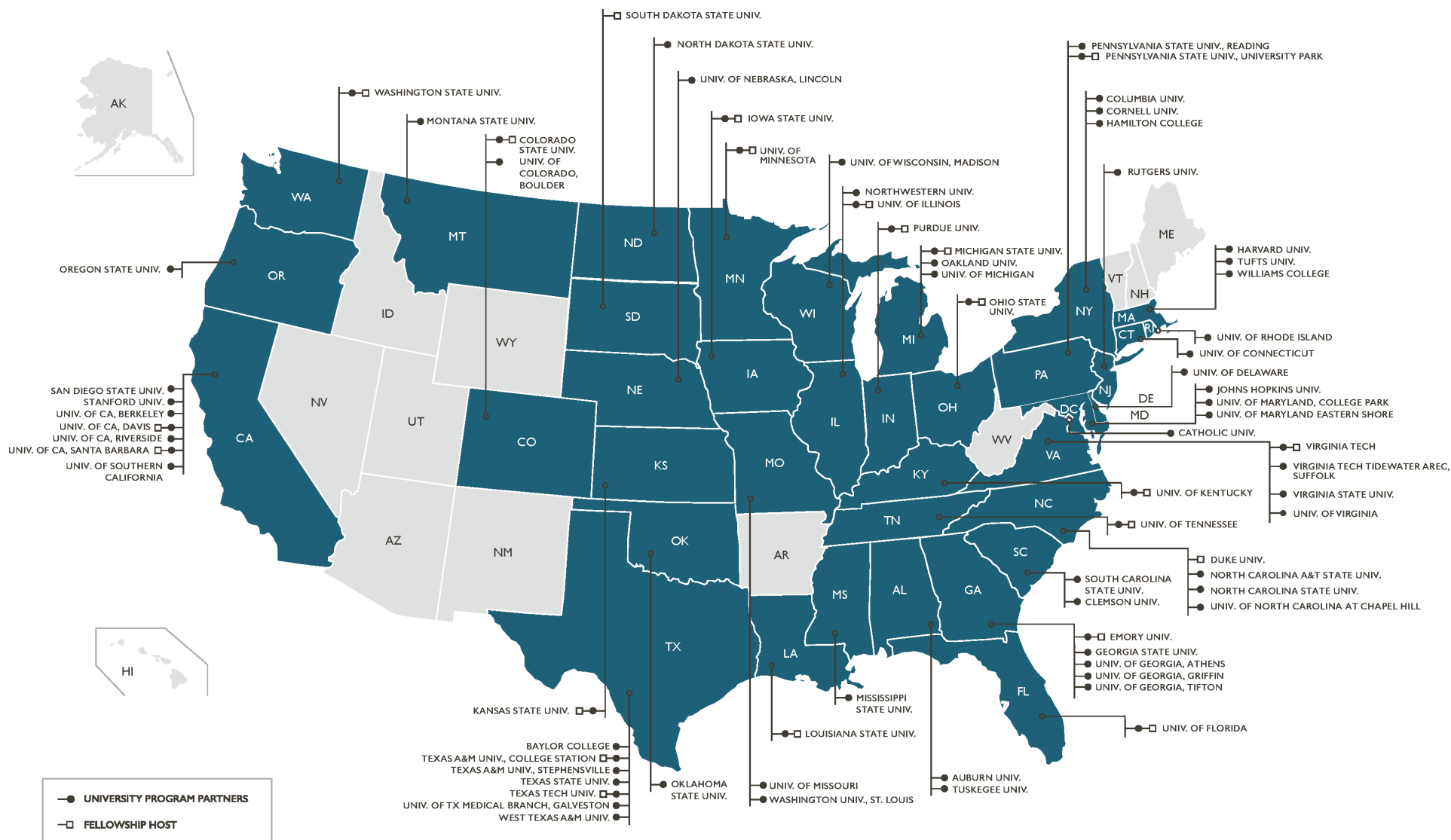
Sorghum and Millet Innovation Lab Program Highlights



Collaborative Research
on Sorghum and Millet

KANSAS STATE
UNIVERSITY

FEED THE FUTURE WORKS WITH U.S. UNIVERSITIES TO FIGHT GLOBAL HUNGER



FROM THE DIRECTOR

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 pearl millet producers while leveraging global benefits to the agriculture industry in the US and worldwide. Supported by USAID, this ten-year program (2013-2023) is building on the legacy of INTSORMIL and is focused on cultivating an interconnected global research network providing innovative technology solutions responding to emerging national agricultural research for development needs. Embedded within our portfolio are numerous activities to build human and institutional capacity that will contribute to the long-term development of the research and development systems in Ethiopia, Niger, Senegal, and Haiti.

Our network has developed numerous national releases of improved sorghum and pearl millet varieties and hybrids. We have established proof-of-concept agronomic interventions to improve yield and reduce loss due to pests and poor seedling vigor for pearl millet. We have developed value-added food products with highly nutritious properties and consumer acceptance studies on new products. We have created the first sensory laboratory for food product evaluation in the West Africa and focused on gender-differentiated technology priorities in Ethiopia and West Africa.

In Ethiopia, strategic and applied advances were made with the discovery of genes conferring anthracnose resistance to sorghum and the official release of a farm adapted variety “Merera” with up to 43% yield gain, the release of a hybrid sorghum varieties, and hedonic testing of new sorghum hybrids with superior functionality and nutritional properties for food products, particularly injera.

In West Africa, our multi-country genomics assisted breeding platforms advanced new sorghum varieties with drought, heat, and striga resistance leading on to national seed registration. Additionally, new materials with superior food and forage quality properties and lines with resistance to sorghum midge and storage pests have been identified and incorporated into the national breeding programs. Applied research has enabled the delivery of a millet head miner control technology through integrated pest management strategies. Small holder farmers, particularly women, are benefiting from the regional scaling of a pearl millet seed ball fabrication and planting technique that provides up to 15% yield gains. Women entrepreneurs, in partnership with national food science teams, have developed and marketed value-added food products from composite flours for porridges fortified with locally available sources of micro-nutrients. In the urban settings “economic” couscous with lower production costs and the completion of consumer acceptance and market penetration studies of new food products are guiding youth and women toward new entrepreneurial opportunities.

Ninety students have benefited from post-graduate degree training; many of whom are “early career” leaders back in their respective national agricultural research systems (NARS) and are benefiting from ongoing mentoring as they contribute to building the crops and food products of the future.

I invite you to read more about the exciting impact the Sorghum and Millet Innovation Lab (SMIL) is having in close partnership with our national collaborators as our global network forges a long-term vision responding to the needs of sorghum and pearl millet producers in the Africa, Haiti, and the world.



Dr. Timothy J. Dalton
Director

PROGRAM PARTNERS

UNITED STATES

Colorado State University
Cornell University
Kansas State University
Kansas State University Western Kansas
Agricultural Research Center
Integrated Pest Management Innovation Lab
Purdue University
Texas A&M AgriLife Research
Texas A&M University
USDA-Agricultural Research Service
Virginia Tech University
West Texas A&M University

HAITI

CHIBAS
Quisqueya University

GERMANY

University of Hohenheim

FRANCE

Centre de Coopération Internationale en
Recherche Agronomique pour le Développement

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





MALI

Institut d'Economie Rurale

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

BURKINA FASO

Institut National de l'Environnement et de Recherches Agricoles

ETHIOPIA

Ethiopian Institute of Agricultural Research

Asosa Research Center • Jimma Research

Center • Melkassa Research Center • Pawe

Research Center • Sirinka Research Center

Haramaya University

Hawassa University

Holleta Biotechnology Center

Oromia Agricultural Research Institute

• Bako Research Center

Tigray Agricultural Research Institute

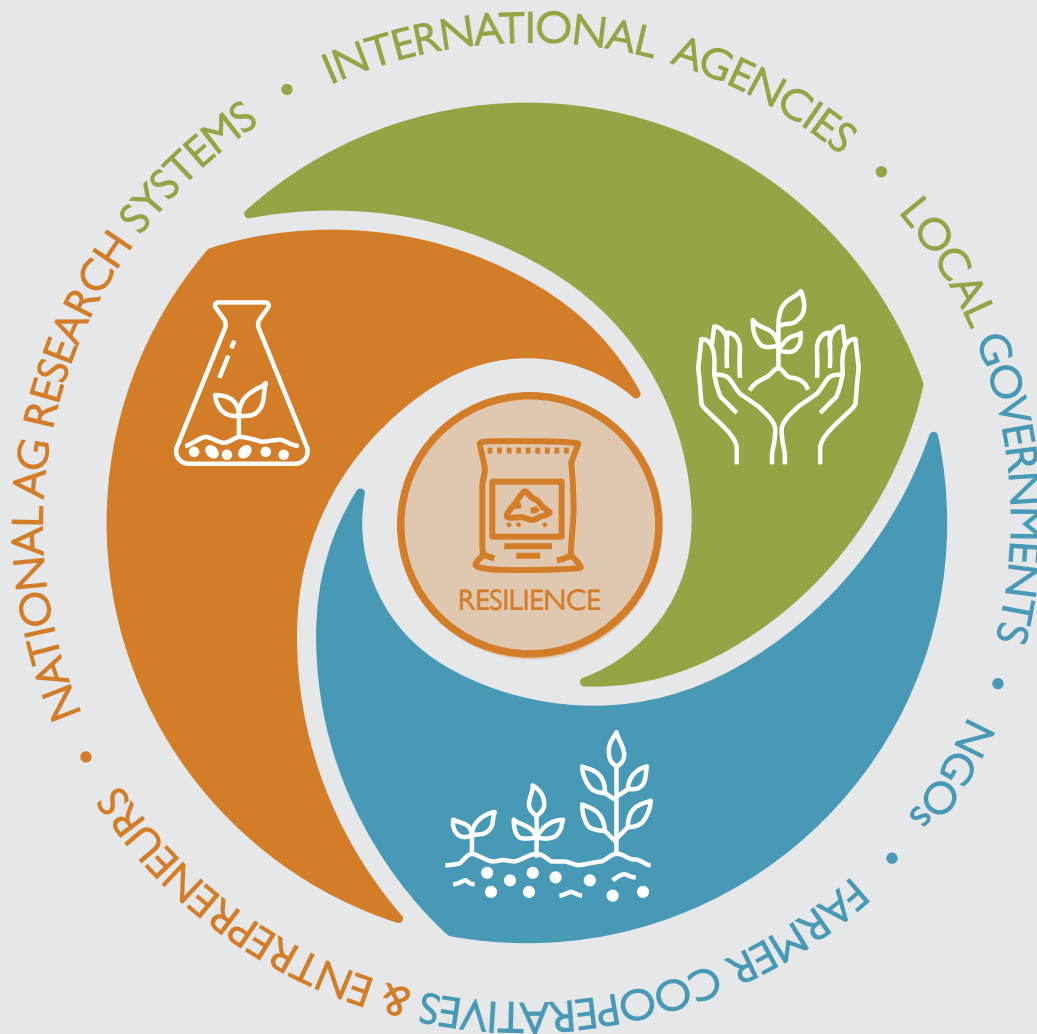
Tigray Regional Program

REPUBLIC OF SOUTH AFRICA

University of Pretoria

RESEARCH FOR DEVELOPMENT

The Sorghum and Millet Innovation Lab's defining objective is to lead **research** for development with the overarching goal of identifying improved techniques and technologies for greater food security and resilience. By setting key priorities that drive real **solutions** to real challenges in collaboration with strategic partners and end users, the Lab is contributing to agricultural **development** on a global scale.



RESEARCH

Scientific inquiry and innovation meet in applied research through national and international partnerships that engage various players from throughout the research and development networks.

PRIORITY SETTING



SOLUTIONS

Research results are employed to identify practical technological and management solutions to address key challenges identified by end users and target groups.

DEVELOPMENT

Promising solutions are scaled up to end user groups and feedback is provided to research teams for continued technological improvement and greater adoptability.

CATALYZING COLLABORATION

BUILDING GLOBAL NETWORKS

The Sorghum and Millet Innovation Lab - in partnership with the University of Pretoria in South Africa - spearheaded the organization and execution of *Sorghum in the 21st Century: Food, Feed and Fuel in a Rapidly Changing World*, a global sorghum conference that took place on April 9-12, 2018 at the Century City Convention Center in Cape Town, South Africa. **The cover image is a picture of some of the attendees.** As the first global conference on sorghum in over 25 years, the event saw the attendance of more than 400 international researchers, industry professionals, government representatives and development specialists from over 40 different countries around a broad variety of sorghum-related topics, including food security, value-added products, genetics, global trade, climate-smart agriculture and more. Based on the success of this meeting <https://21centurysorghum.com/> another **Global Sorghum Conference is scheduled for June, 2023, in Montpellier, France.**

The Sorghum and Millet Innovation Lab co-hosted the 2018 West Africa Regional Pearl Millet Convening targeted at researchers and stakeholders in pearl millet from Senegal, Niger, Mali and Burkina Faso. Nearly 90 major actors from across the West Africa pearl millet value chain came together at the Centre d'Etude Régional pour l'Amélioration de l'Adaptation à la Sécheresse (CERAAS) in Thies, Senegal in an exchange of needs and opportunities by pearl millet stakeholders (including input suppliers, farmers, processors, etc.) with agricultural researchers focused on technological innovation.



(Above) Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet (SMIL) Annual Review Meeting held in Niamey, Niger, in 2019.

(Below) Nearly 90 stakeholders from across the West Africa pearl millet value chain came together at a regional convening in September 2018 in Thies, Senegal.



BUILDING LOCAL CAPACITY

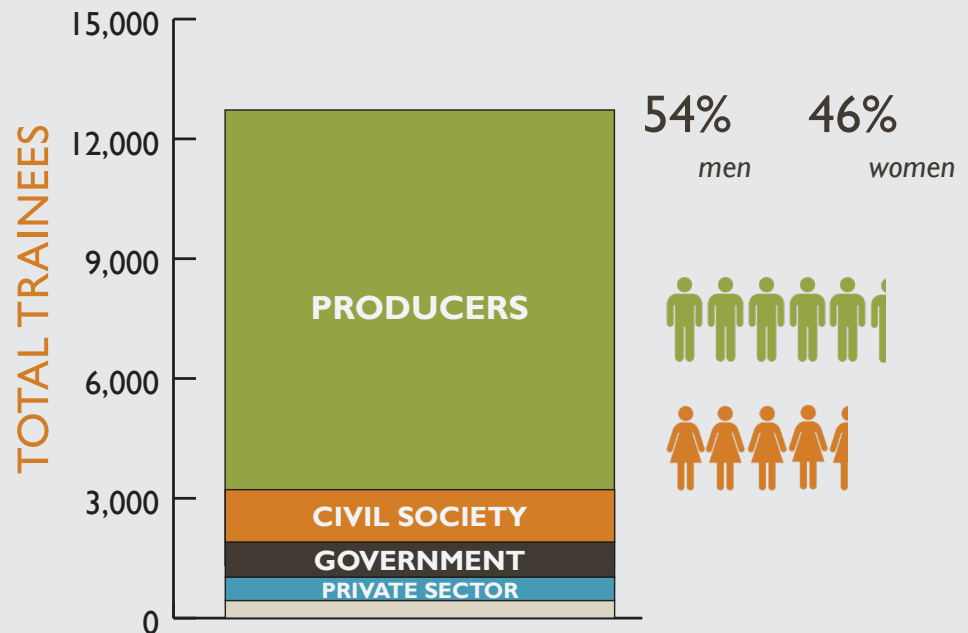


The Sorghum and Millet Innovation Lab contributes to building local human and institutional capacity in our target countries to create an environment for innovation and entrepreneurship. Over 10,000 trainees participated in outreach programming targeted at new cereal production techniques, crop protection, storage management, marketing and added-value products.

Through targeted training, sorghum-producing and millet-producing communities are becoming more resilient to emerging threats and better positioned to take advantage of new technologies, crop management practices, and entrepreneurial opportunities.

TOTAL TRAINING SESSIONS: 180

TOTAL INDIVIDUALS TRAINED: 12,500



DRIVING RESILIENCE

The Sorghum and Millet Innovation Lab is a cutting-edge research consortium focused on improving the resilience and productivity of sorghum and pearl millet value chains in the semi-arid environments of Ethiopia and West Africa. Our innovations and technologies raise incomes and improve nutritional outcomes through multidisciplinary problem solving in three areas of inquiry and in cross-cutting themes on gender, the environment and nutrition.



GENETIC ENHANCEMENT

The **GENETIC ENHANCEMENT** area of inquiry develops innovative approaches to integrate genomics-assisted breeding, regional phenotyping, and farmer participation to improve resistance against important yield-robbing stresses while enhancing the functionality for food, feed and forage of both sorghum and millet.



PRODUCTION SYSTEMS MANAGEMENT

In the **PRODUCTION SYSTEMS MANAGEMENT** area, the lab is developing a novel innovation to improve seedling establishment, and eventual yield, through the adaptation of seedballs to varying agroecological and social environments. Integrated pest management of the millet head miner and the search for host plant resistance against diseases and insects focus on preserving yield, rather than losing it to the vagaries of harsh environmental and biological stresses.



VALUE-ADDED PRODUCTS & MARKET DEVELOPMENT

The **VALUE-ADDED PRODUCTS & MARKET DEVELOPMENT** area focuses on creating new products through supportive entrepreneurial activity in food product incubation centers that enhance consumer value and acceptance of healthy and convenient sorghum- and millet-based foods.



ENSURING OPPORTUNITY



GENDER IN RESEARCH

With the aim of assuring the greatest overall impact of its research, the Sorghum and Millet Innovation Lab places strong emphasis on incorporating gender awareness into all of its research activities. It is through this that the Lab assures the creation of equitable opportunity for both men and women smallholders, researchers, entrepreneurs and beyond.

By integrating gender into the research process, each project is expected to identify the major gender issues its research team anticipates encountering, how they will be addressed and how projects will promote equitable participation by women. The gender implications of those projects that are closer to the delivery of new technologies, knowledge, production systems or products often require the greatest attention.

GENDER ROLES IN SORGHUM PRODUCTION, PROCESSING AND UTILIZATION IN ETHIOPIA

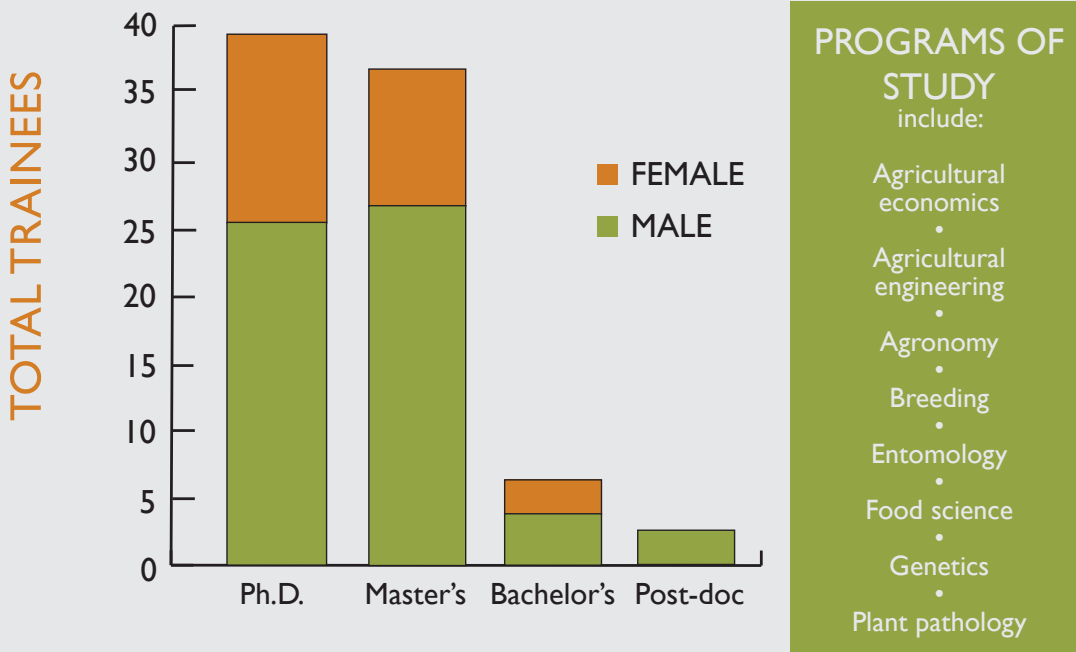
The Sorghum and Millet Innovation Lab commissioned a gender study to assess gender roles and sorghum production/utilization by region in Ethiopia. The regional multi-disciplinary research teams implemented village-level data collection in six different geographical areas using focus group interviews and rapid rural appraisals with the objective of identifying regional differences and similarities. The data from those interviews was aggregated into individual regional reports, and made available on the the Sorghum and Millet Innovation Lab website: <https://smil.k-state.edu/gender-in-research>

INVESTING IN THE FUTURE

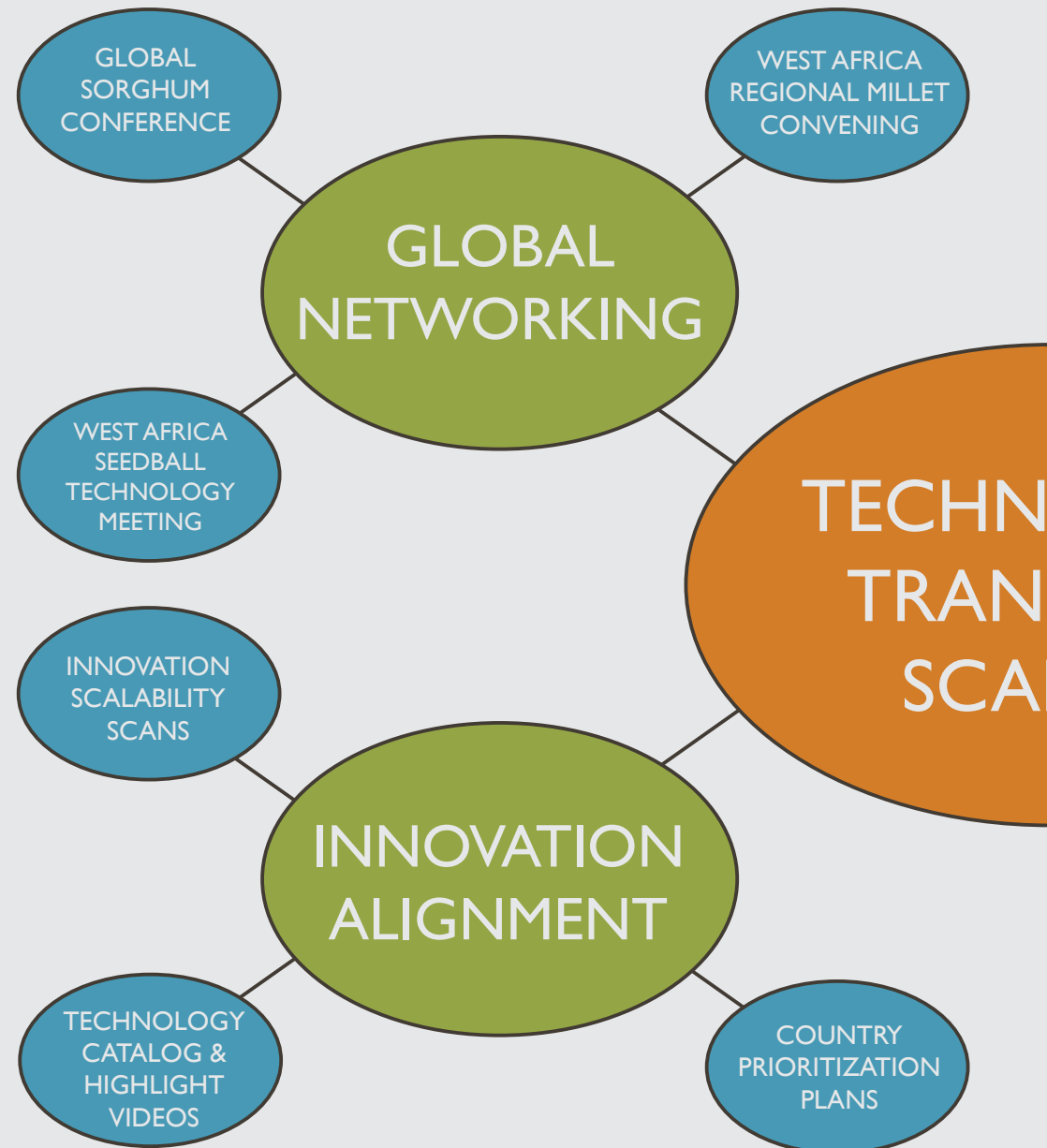
While the Sorghum and Millet Innovation Lab focuses energy and many resources toward the development of new technologies and innovations for the improvement of food and income security across its target populations, it also understands that long-term sustainability and success belongs to future generations.

It is with this in mind that the Lab has prioritized its investment toward training the next generation of researchers, policy makers and entrepreneurs. Through graduate studies, undergraduate studies and beyond, the Lab is preparing young people for a future of leadership and creativity so they are ready to take on some of the world's most challenging questions. Nearly 100 graduate and undergraduate students have had their education and training funded by the Lab.

THE NEXT GENERATION OF LEADERS



INNOVATING TECHNOLOGIES





Sorghum and millet are key food, feed, and fuel crops for hundreds of millions of people worldwide, and the Sorghum and Millet Innovation Lab is actively working to develop solution-based technologies along these value chains. In order for those technologies to appropriately address key challenges and make it into the hands of the target end users, the Lab plays an important role in the technology transfer and scaling process. It is a catalyst that creates and nurtures networks of NGOs, cooperatives, the private sector, extension and research in order to tackle the challenges in innovation, adoption and marketing of technologies and solutions.

In the Sorghum and Millet Innovation Lab, this is being accomplished through four main priority areas:

- Global networking
- Cross learning
- Innovation alignment
- Strategic partnerships

By actively identifying opportunities to facilitate connections between key players as well as improved feedback about innovations from end users to developers, the Lab is building pathways for continued technology innovation for years to come.

GENERATING SOLUTIONS



PEARL MILLET SEEDBALLS FOR HIGHER YIELDS

CHALLENGE:

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. Sahelian farmers also 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 or produce enough to sell their crops for income.

SOLUTION:

Seed balls are a sowing technique aimed at the improvement of plant establishment with dry sowing, which can provide up to a 15% yield gain. By creating microenvironments that can capture moisture and make nutrients more readily available, the seedball has the potential to support seedling emergence and stand establishment, even in the face of intermittent drought. Fabrication of the seedballs requires a combination of products that are easily accessible to subsistence farmers in the Sahel, including soil, wood ash, urine, organic matter, seeds and additives (e.g. nutrients, pesticides). They are a low-cost technology with low application risk for farmers, but with high potential for improved yields.

PRINCIPAL INVESTIGATORS:

Ludger Herrmann - *University of Hohenheim (Germany)*

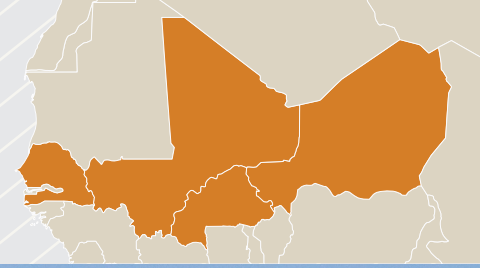
Charles Nwankwo - *University of Hohenheim (Germany)*

IN-COUNTRY PARTNERS:

Ali Aminou - *Fuma Gaskiya Farmer Association (Niger)*

Hannatou Moussa Oumarou - *INRAN (Niger)*

West Africa



PARASITOID WASPS FOR MILLET HEAD MINER CONTROL

CHALLENGE:

Pearl millet serves as a staple crop to millions of smallholder farmers and their families around the world. But pearl millet has its weaknesses, and one of those is its susceptibility to certain insect pests. Across the African Sahel - where millet is an irreplaceable base to the diets of humans and livestock alike - the millet stem borer and millet head miner are considered major chronic millet pests, known for wreaking havoc and causing major destruction to entire fields of production.

SOLUTION:

The technology under development focuses on the release of a naturally-occurring parasitoid wasp that targets both the head miner and stem borer and kills them, effectively controlling the population. Parasitoid wasps (*Habrobracon hebetor*) are reared in jute bags with millet grain, millet flour, rice moth larvae (*Corcyra cephalonica*) and two mated *H. Hebetor* females. Offspring emerge from the bags and disperse to the millet fields to control the millet head miner and borer insects. A set of 15 bags yield a population of approximately 1,000 parasitoids, which provides coverage of up to three square kilometers, resulting in a potential yield gain of up to 34% compared to unprotected fields of millet.

PRINCIPAL INVESTIGATOR:

Malick Ba - ICRISAT - Niamey (Niger)

IN-COUNTRY PARTNERS:

Ali Aminou - Fuma Gaskiya Farmer Association (Niger)

Hannatou Moussa Oumarou - INRAN (Niger)



GENERATING SOLUTIONS

WEST AFRICA NETWORK FOR CROP IMPROVEMENT



CHALLENGE:

Sorghum improvement in West Africa faces a host of challenges, both in terms of capacity as well as resources. National programs are working to address local producer and user needs but frequently with limited funds, researchers, staff and infrastructure. The result has been limited success in varietal adoption and a rate of improvement that is not sufficient for the necessary impacts on food and income security in the region.

SOLUTION:

The Sorghum Adaptation in West Africa with a Genomics-Enabled Breeding Network (SAWAGEN) project creates a defined network of national researchers, international collaborators and farmer organizations aimed at leveraging capacity to develop and deliver demand-driven varieties to farmers. It is built on four separate platforms – local adaptation breeding, genetic mapping research, physiological mapping research, and broad adaptation breeding – and links researchers across those platforms in a hypothesis-driven, goal-oriented research approach. The SAWAGEN spans Senegal, Burkina Faso, Togo and Niger and reinforces existing regional breeding network initiatives to further accelerate interdisciplinary solutions to key crop improvement challenges across the Sahel.

PRINCIPAL INVESTIGATOR:

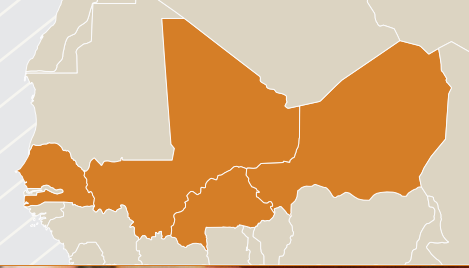
Geoffrey Morris - *Colorado State University (USA)*

IN-COUNTRY PARTNERS:

Cyril Diatta - *ISRA/CERAAS (Senegal)*

Aissata Mamadou - *INRAN (Niger)*

West Africa



FOOD PRODUCTS TO MEET MARKET DEMAND

CHALLENGE:

Sorghum and millet are the key ingredients to countless West African staple dishes. While these foods are an important source of nutrition for individuals of all ages and backgrounds, they are often prepared using traditional methods that are labor-intensive and require multiple hours of preparation, a responsibility that typically falls to the women of the household. With increasing urbanization and disposable income, as well as a deeper understanding and desire for nutritionally-balanced diets, consumer demand for these ready-made products is rising.

SOLUTION:

The initiative collaborates with urban and rural businesses, cooperatives and entrepreneurs to develop high-quality agglomerated products such as couscous and innovative composite flours that can be transformed into multiple products such as porridges and biscuits. These products are labeled, packaged, and targeted at consumers as ready-to-prepare and nutritious alternatives to traditional products. In addition to evaluating preferences for food product type and processing method, testing has also been conducted around the fortification of grain-based products with locally available, highly nutritious ingredients such as moringa and baobab with encouraging results.

PRINCIPAL INVESTIGATOR:

Bruce Hamaker - *Purdue University (USA)*

IN-COUNTRY PARTNERS:

Moustapha Moussa - *INRAN (Niger)*

Cheikh Ndiaye - *ITA (Senegal)*



GENERATING SOLUTIONS



WHITE SORGHUM HYBRIDS FOR COMMERCIAL SEED SYSTEM

CHALLENGE:

Despite sorghum's important place in the Ethiopian economy and culture, one area of challenge remains for the sorghum industry – the lack of a commercial hybrid sorghum seed system. A sustainable and effective commercial seed system can offer greater consistency and reliability to producers which can result in better performing, higher quality sorghum crops that can be marketed at a higher value.

SOLUTION:

In an effort to address this need while simultaneously developing better varieties with improved adaption to local production environments, researchers have registered and released a white sorghum hybrid variety in Ethiopia that is particularly well adapted to lowland growing conditions. The hybrid, ESH 5, is an early-maturing and high-yielding variety demonstrating strong drought tolerance. It also demonstrates good qualities for injera production (injera is a staple bread product consumed throughout Ethiopia), making it a desirable variety for both producers and consumers. The release of this hybrid within Ethiopia is a key step toward the establishment of a strong hybrid sorghum breeding program that can serve as a catalyst for the development of a commercial sorghum seed system.

PRINCIPAL INVESTIGATOR:

Gebisa Ejeta - *Purdue University (USA)*

IN-COUNTRY PARTNERS:

Habte Nida - *EIAR (Ethiopia)*

Alemu Tirfessa - *EIAR (Ethiopia)*



Ethiopia

IMPROVED SORGHUMS FOR FOOD APPLICATIONS

CHALLENGE:

More families in Ethiopia are purchasing their injera from local vendors instead of preparing it at home due to increased disposable income and the rise of the middle class. While teff has traditionally served as the base for injera, sorghum is commonly incorporated into injera fabrication, thanks to both its affordability and availability. However, due to its physio-chemical traits, sorghum tends to underperform in the making of injera, which limits its use as a base ingredient and keeps the price of injera higher with the dependence on teff.

SOLUTION:

In an effort to improve the functionality of sorghum in commercial grain-based food products, improved highly-digestible (IHD) sorghum lines have been developed and have displayed improved performance in food processing. These IHD lines are being tested in Ethiopian environments in order to evaluate production constraints and opportunities for local farmers. Food scientists have worked with food product development labs and local entrepreneurs to assess the performance of the IHD sorghum. Consumer preference studies show that injera made from blends with these improved sorghum lines performs as well as 100% teff injera and is equally preferred.

PRINCIPAL INVESTIGATOR:

Joseph Awika - *Texas A&M University (USA)*

IN-COUNTRY PARTNERS:

Kebede Abegaz - *Hawassa University (Ethiopia)*

John Taylor - *University of Pretoria (South Africa)*



GENERATING SOLUTIONS



RESISTANCE TO FUNGAL PATHOGENS IN SORGHUM

CHALLENGE:

Anthraxnose is a widespread disease caused by a fungus that can have devastating effects on sorghum production. It occurs in numerous locations around the world, and is especially prevalent in areas of high humidity, including many regions in Africa and the southern United States. Smallholder farmers in Ethiopia and other regions often experience limited access to inputs and fungicide treatment options, leaving them especially vulnerable to anthracnose.

SOLUTION:

Through innovative genomics approaches paired with in-country breeding teams, disease-resistant sorghum varieties to anthracnose have been quickly developed. One variety, Merera, with up to a 43% yield gain has been officially registered and farmer-level seed distribution and seed multiplication is underway in Ethiopia.

PRINCIPAL INVESTIGATOR:

Tesfaye Mengiste - *Purdue University (USA)*

IN-COUNTRY PARTNERS:

Getachew Ayana - *EIAR (Ethiopia)*

Kebede Desalegn - *Bako Agricultural Center (Ethiopia)*



USA & GLOBAL SORGHUM PRODUCTION BENEFITS

GENOMICS-ENABLED BREEDING NETWORKS:

The SMIL/USAID investment to establish global genomics-enabled breeding networks is having both short- and long-term impacts. These networks are leveraging unique capacities to accelerate the response of our National Agricultural Research System (NARS) partners to address their national sorghum and millet plant breeding goals. These decentralized breeding networks based on the NARS, provide a platform where new waves of early career scientists can integrate their novel genomics tools and training into traditional breeding programs.

USA PRODUCTION BENEFITS:

In Haiti, our program has had remarkable success through the creation of a platform which pairs the genomics mapping and bioinformatics capacity of US land grant university departments with a traditional small country breeding program. This has been the basis for unique discoveries to respond sugarcane aphid pressure, climate adaptation and end-use requirements in Haiti. The SMIL/USAID support to establish this global genomics-enabled breeding network has resulted in global access to unique sugarcane aphid (SCA) resistant materials. This has benefited the US sorghum industry and a “no strings attached” private sector funding was provided by a US seed company to further the SCA science.

This Haiti experience is one example of the SMIL/USAID program’s strategic support to cutting-edge research and a truly global genomics enabled breeding network that is **accelerating genetic exchange for the benefit of US sorghum producers** as well as our USAID target countries/regions.

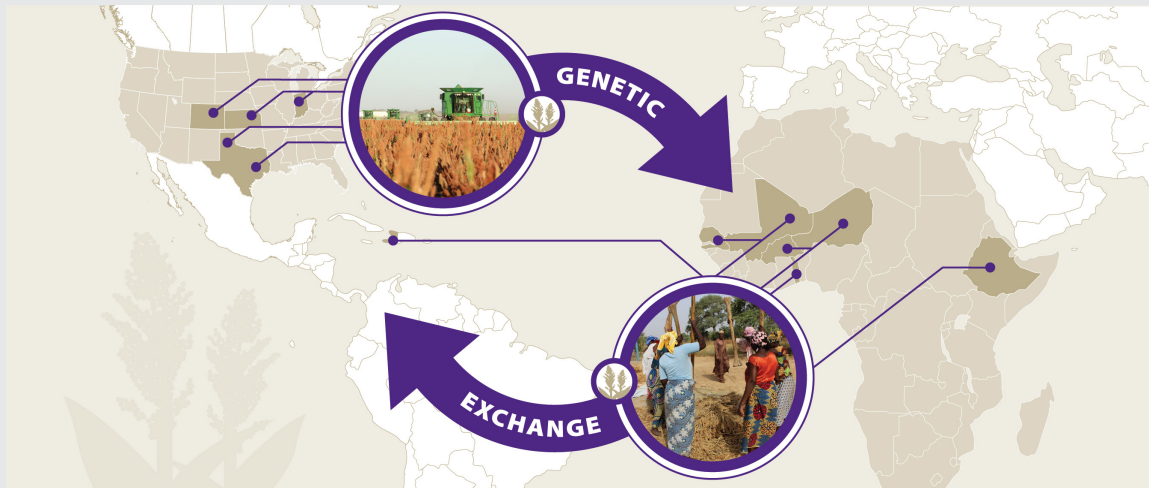


GLOBAL PARTNERSHIPS

GENETIC EXCHANGE

The Sorghum and Millet Innovation Lab has set its sights on continued innovation and solution development. The Lab's research projects align with its core strategies:

- Building a coalition of science and industry around sorghum and millet
- Incubating and nurturing a new wave of feed and food products
- Creating a research investment plan that leverages key funders for maximum impact of donor funding



The cross-continental exchange of genetic information among collaborating universities, research centers, and other agricultural institutions is key to accessing sorghum's maximum potential in the field and beyond.

The Sorghum and Millet Innovation Lab remains focused on the advancement of technologies, practices and solutions toward broader scaling and end-user uptake. The Lab is proactive in linking projects with next users of information and technologies - including NGOs, researchers, private industry and consumers - in developing networks and awareness of programmatic activities and in the marketing of innovations.





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on Sorghum and Millet



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