



FEED THE FUTURE

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



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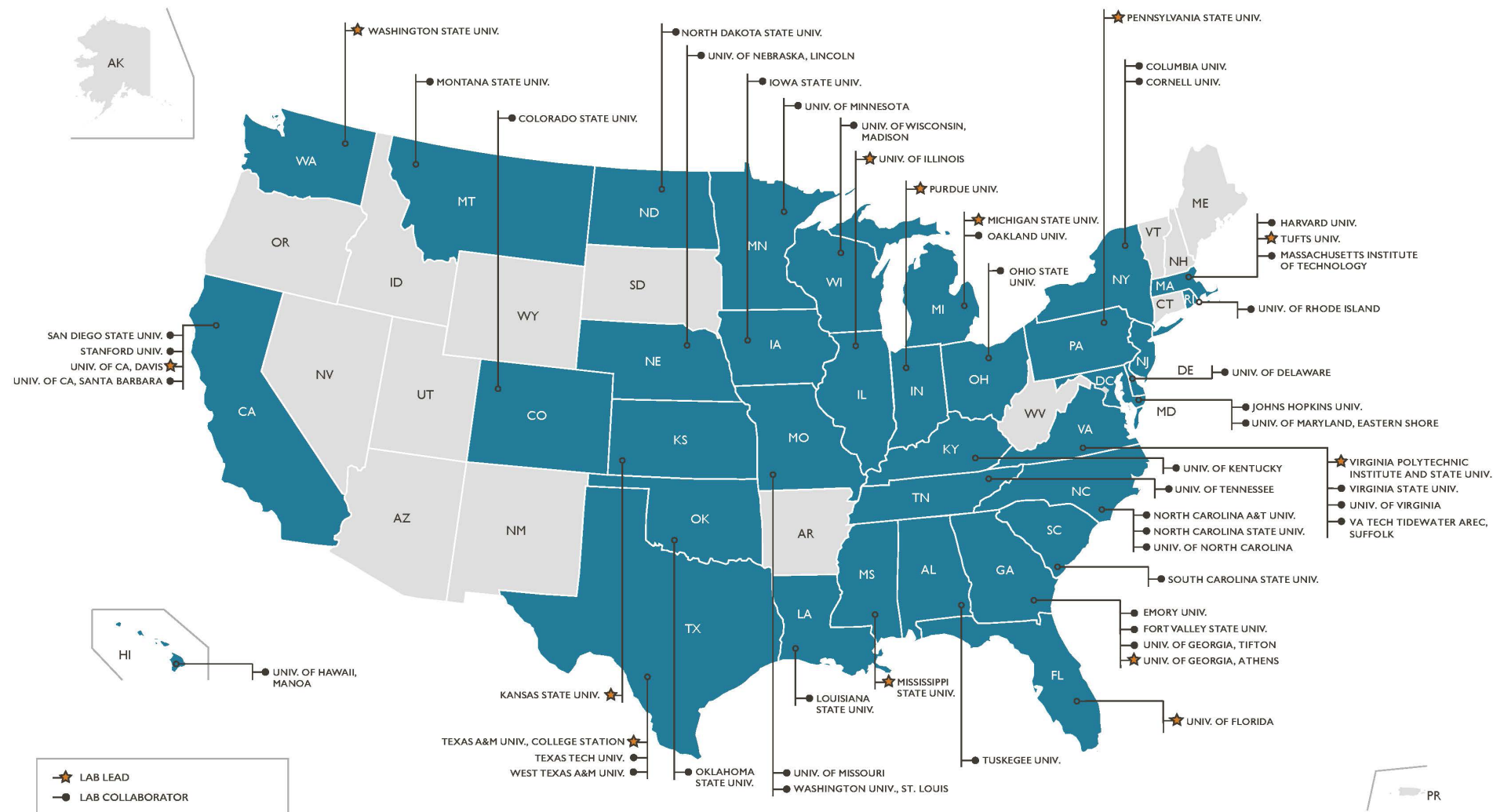
PHASE I HIGHLIGHTS & IMPACTS



Collaborative Research
on Sorghum and Millet

KANSAS STATE
UNIVERSITY

FEED THE FUTURE INNOVATION LABS HELP FIGHT GLOBAL HUNGER



The Feed the Future initiative partners with universities throughout the world. This map represents U.S. universities that are part of the Feed the Future Innovation Lab network. For more information and updates, visit www.feedthefuture.gov or follow on Twitter @FeedtheFuture.

2019-009

FROM THE DIRECTOR

The Feed the Future Innovation Lab for Collaborative Research on Sorghum and Millet completed its first five-year phase from 2013 to 2018 and launched activities for a second phase that will end in 2023. This report focuses on our historical achievements and presents our strategic vision for the second phase. In many instances, the programmatic objectives set forth in the first phase have remained constant with the same country focus and a few minor revisions in project activities plus the addition of a pearl millet breeding project and one focusing on sorghum pathology. Embedded within the project portfolio are numerous activities to build human and institutional capacity that will contribute to the development of the research and development systems in Ethiopia, Niger and Senegal.

Numerous important advances were made in the first phase including the release of improved sorghum varieties and hybrids, the establishment of proof-of-concept on agronomic interventions to reduce yield loss due to pests and poor seedling establishment for pearl millet, the development of value-added food products with highly nutritious properties, consumer acceptance studies on new food products and the publication of gender-differentiated technology priorities in Ethiopia. The program will capitalize on the momentum generated in the first phase and build during the second phase for continued impact. This will be accomplished with a diversified project portfolio spanning both the sorghum and pearl millet value chains.

In Ethiopia, strategic and applied advances

were made with the discovery of genes conferring anthracnose resistance to sorghum, the release of a hybrid sorghum variety, and hedonic testing of new sorghum hybrids with superior functionality and nutritional properties for food products. In West Africa, breeding programs advanced new sorghum varieties with drought and heat resistance, new materials with superior food and forage quality properties and identified lines with resistance to sorghum midge and storage pests. Applied research to control the millet head miner through integrated pest management strategies was completed as well as improved agronomic techniques on pearl millet seedball fabrication and planting. Value-added food product development continues with the development of composite flours for porridges fortified with locally-available sources of micronutrients, the improvement of “economic” couscous with a lower cost of production, and the completion of consumer acceptance and marketing studies on new food products.

Sixty-eight students either completed their degrees or advanced to near completion during the first phase. Many of these students are returning to their respective national research systems and will be mentored as junior scientists in the second phase. Mentors will be senior researchers in national programs and scientists from outside Africa to build the next generation of agricultural technologies. These scientists will contribute to building the crops of the future in the coming years.

I invite you to read about our achievements and objectives and join us on this fantastic journey.



Jimmy Dalton

Dr. Timothy J. Dalton
Director

PROGRAM PARTNERS

UNITED STATES

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

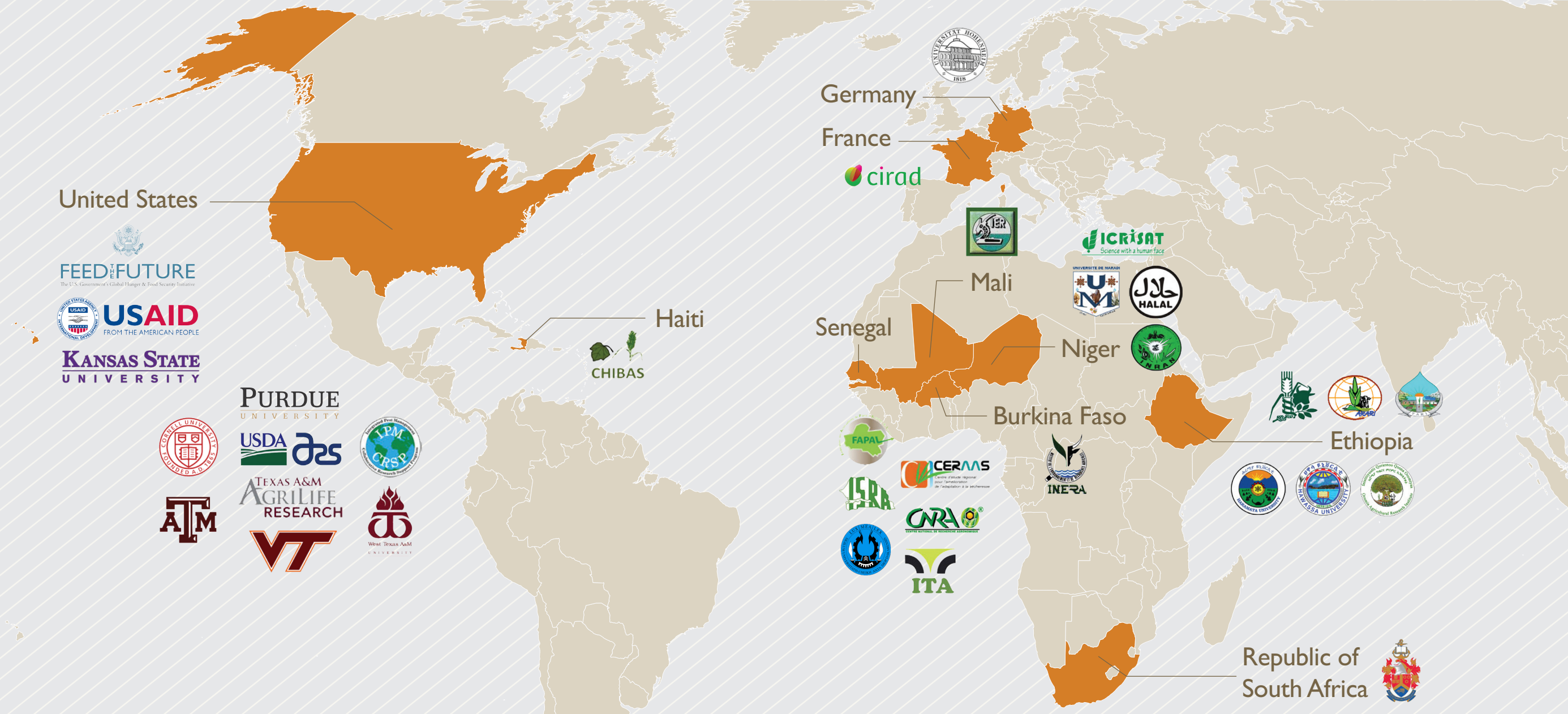
University of Hohenheim

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

In a capstone component of the program's first five years, 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. 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.

Later in the year, the 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) Approximately 400 participants from 40 different countries were in attendance at the 2018 Sorghum in the 21st Century global sorghum conference.

(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.



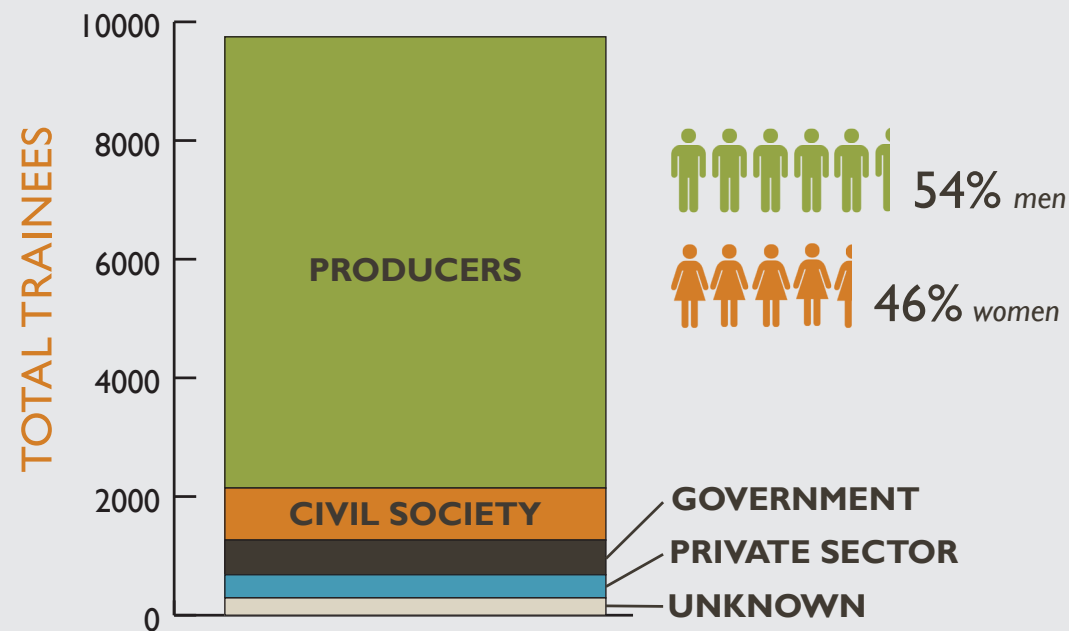
BUILDING LOCAL CAPACITY



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. In the first phase, nearly 10,000 trainees participated in outreach programming targeted at new cereal production techniques, crop protection, storage management, marketing and added-value products.

Through targeted trainings, sorghum- 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 TRAININGS: 120
TOTAL INDIVIDUALS TRAINED: 9,749



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

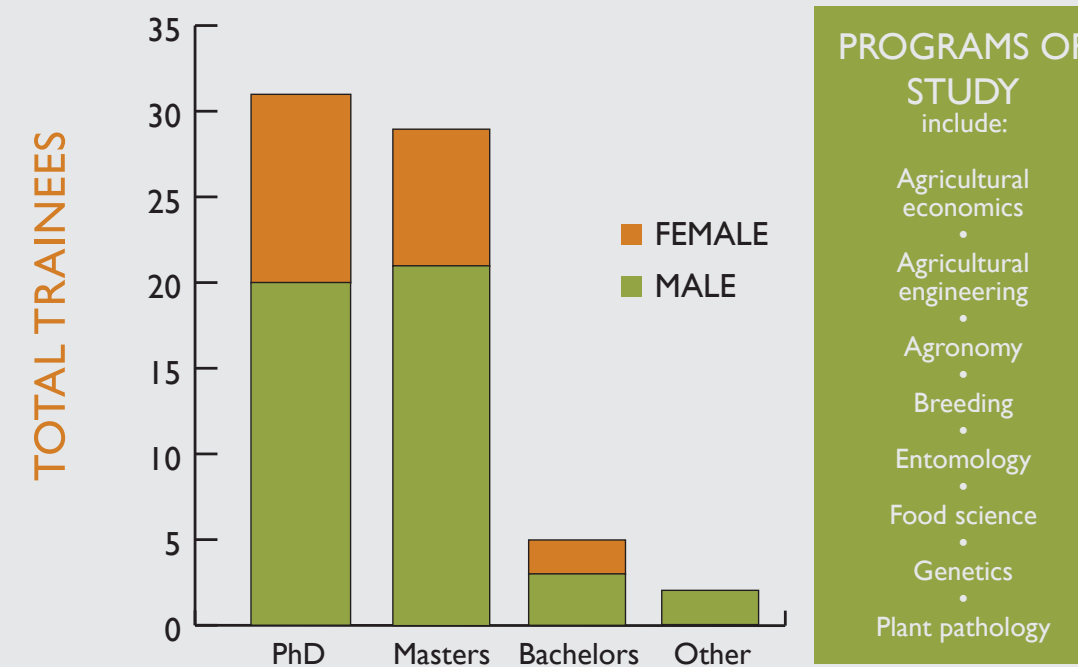
During its first five-year phase, the Sorghum and Millet Innovation Lab commissioned a gender study to assess gender roles and sorghum production/utilization by region in Ethiopia. The regional multi-disciplinary research teams implemented village-level data collection in six different geographical areas 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 publicly in 2019 via the Sorghum and Millet Innovation Lab website.

INVESTING IN THE FUTURE

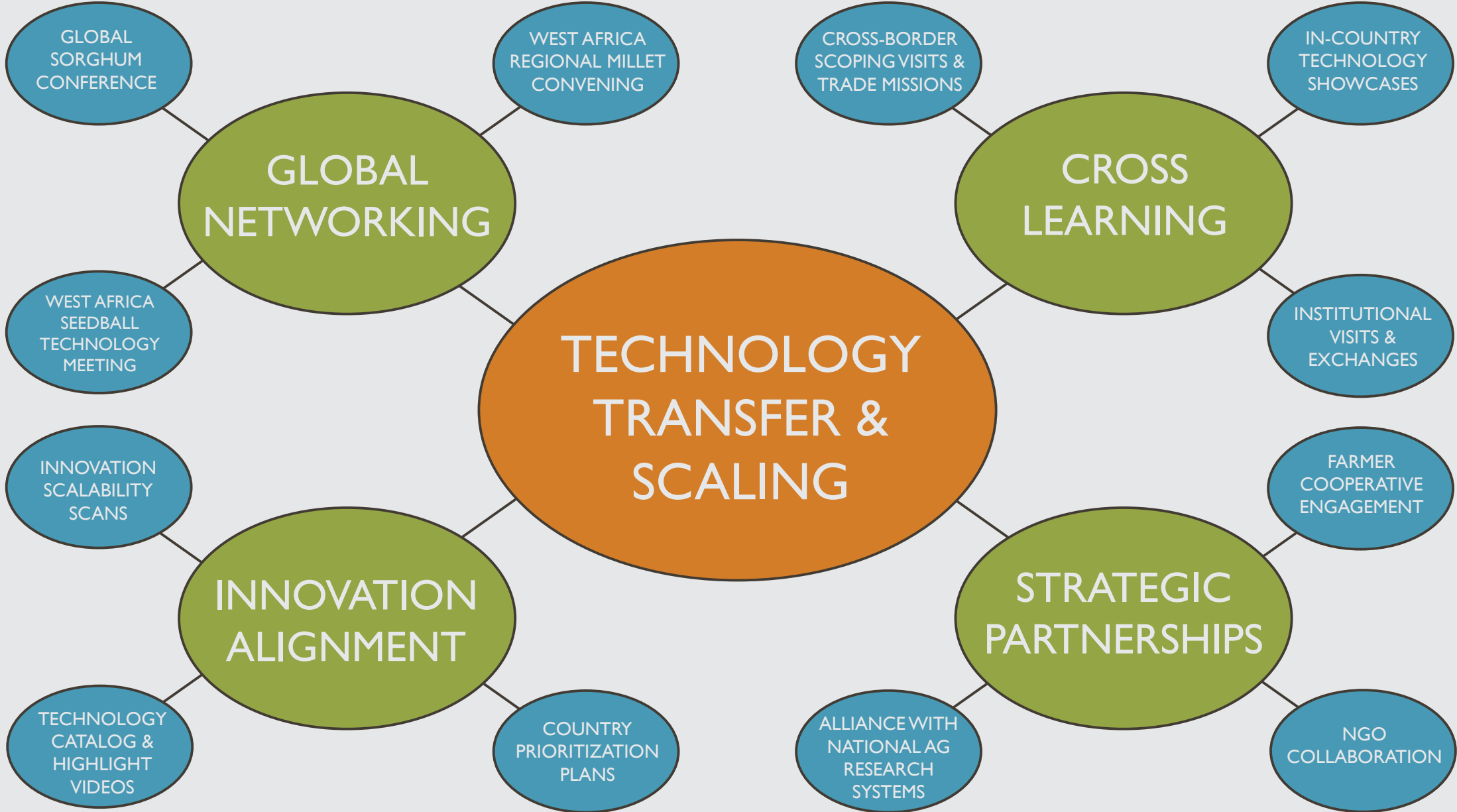
While the Sorghum and Millet Innovation Lab focuses many of its resources and energies towards the development of new technologies and innovations for the improvement of food and income security across its target populations, it also understands that the keys to long-term sustainability and success will be in the hands of future generations.

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

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 of the challenges in innovation, adoption and marketing of technologies and solutions.

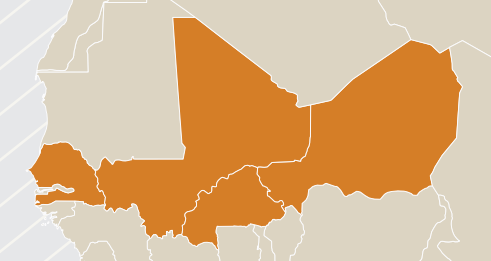
In the Sorghum and Millet Innovation Lab, this is being accomplished through four main priority areas:

- 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

West Africa



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 UNDER DEVELOPMENT:

Seedballs are a sowing technique for semi-arid areas, especially aimed at the improvement of plant establishment with dry sowing. 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)*

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 UNDER DEVELOPMENT:

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)*

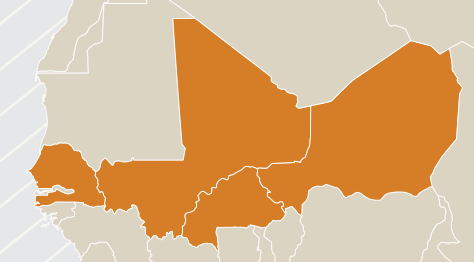
IN-COUNTRY PARTNERS:

Ali Aminou - *Fuma Gaskiya Farmer Association (Niger)*
Hannatou Moussa Oumarou - *INRAN (Niger)*



GENERATING SOLUTIONS

West Africa



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 UNDER DEVELOPMENT:

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 - Kansas State University

IN-COUNTRY PARTNERS:

Cyril Diatta - ISRA/CERAAS (Senegal)

Aissata Mamadou - INRAN (Niger)

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 UNDER DEVELOPMENT:

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 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 UNDER DEVELOPMENT:

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 towards the establishment of a strong hybrid sorghum breeding program that can then serve as a catalyst for the development of a commercial sorghum seed system.

PRINCIPAL INVESTIGATOR:

Gebisa Ejeta - *Purdue University (U.S.)*

IN-COUNTRY PARTNERS:

Habte Nida - *ELAR (Ethiopia)*

Alemu Tirfessa - *ELAR (Ethiopia)*

IMPROVED SORGHUMS FOR FOOD APPLICATIONS

CHALLENGE:

More and 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 UNDER DEVELOPMENT:

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 (U.S.)*

IN-COUNTRY PARTNERS:

Kebede Abegaz - *Hawassa University (Ethiopia)*

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



GENERATING SOLUTIONS



RESISTANCE TO FUNGAL PATHOGENS IN SORGHUM

CHALLENGE:

Anthrachnose 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 UNDER DEVELOPMENT:

Research teams have identified two genes in Ethiopian sorghum lines that harbor resistance against anthracnose. Breeding these resistant lines with susceptible ones will allow sorghum to flourish under anthracnose pressure even without the use of fungicides. These genes will increase host-plant resistance against the disease and will be crossed with farmer-preferred sorghum lines to produce more resilient locally-adapted varieties.

PRINCIPAL INVESTIGATOR:

Tesfaye Mengiste - *Purdue University (U.S.)*

IN-COUNTRY PARTNERS:

Getachew Ayana - *EIAR (Ethiopia)*

Kebede Desalegn - *Bako Agricultural Center (Ethiopia)*

SUGARCANE APHID RESISTANT SORGHUM GERMPLASM

CHALLENGE:

The sugarcane aphid is a destructive sorghum pest found worldwide that began progressively expanding its range across the U.S. and North America in 2013. Its impact has been seen in nearly all major sorghum-producing areas, and it has caused crop devastation for countless sorghum producers. The most promising line of defense against the sugarcane aphid is in the development of resistant sorghum lines, but breeding for resistance is a slow and painstaking process.

SOLUTION UNDER DEVELOPMENT:

Breeders and entomologists initiated research on the sugarcane aphid under the INTSORMIL program in southern Africa after an outbreak of the pest in the early 1980's. When the aphid appeared in the United States, researchers turned to the same sources of host-plant resistance and integrated those resistant varieties with the best performing parental lines of the 2010s. In addition, heavy infestation of the sugarcane aphid in Haiti has allowed for novel collaboration between tropical growing environments and temperate U.S.-based ones. In 2018, researchers formally registered and released 19 elite breeding lines with resistance to the sugarcane aphid.

LED BY:

Texas AgriLife - *Texas A&M University (U.S.)*

INTSORMIL - *University of Nebraska (U.S.)*

Sorghum and Millet Innovation Lab - *Kansas State University (U.S.)*

CHIBAS (*Haiti*)



VISION FOR TOMORROW



DRIVING INNOVATION

Having received a five-year program extension and additional commitment of \$14 million from USAID in July 2018, the Sorghum and Millet Innovation Lab has set its sights on continued innovation and solution development into its second phase. The Lab's new research projects will align with its original core strategies of:

- 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 dollars

The second phase of the Sorghum and Millet Innovation Lab will see the advancement of technologies, practices and solutions developed in Phase I towards broader scaling and end user uptake. The Lab will be 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. It will also see a continued emphasis in student trainings and capacity-building initiatives, coupled with an exploration of new opportunities for cutting-edge innovation along the sorghum and millet value chains.

The Lab philosophy is one of adaptation to emerging challenges and opportunities combined with a result-based analysis of each project's contribution to national and regional agricultural objectives. During the second five-year phase, the program will promote research and development activities that demonstrate impact for target end-users, whether that be producers, consumers, processors or the next generation of scientists.





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