

2006 Annual Report

INTSORMIL

**Sorghum/Millet Collaborative
Research Support Program (CRSP)**



**Fighting Hunger and Poverty with Research
... a team effort**

Funding support through the Agency for International Development

INTSORMIL GRANT NUMBER
LAG-G-00-96-90009-00

Farmers in the Village of Gabi, Niger Show Their Intent to Continue Participating in the INTSORMIL Integrate Initiative

Photos by: Simon Tripp, Battelle

INTSORMIL

2006 ANNUAL REPORT

Fighting Hunger and Poverty with Research
... A Team Effort

Grain Sorghum/Pearl Millet Collaborative
Research Support Program (CRSP)

This publication was made possible through support provided by the U.S. Agency for International Development, under the terms of Grant No. LAG-G-00-96-90009-00. The opinions expressed herein are those of the author(s) and do not necessarily reflect the views of the U.S. Agency for International Development.

INTSORMIL Publication 06-01

Report Coordinators
John M. Yohe, Program Director
Kimberly Christiansen and Joan Frederick

For additional information contact the INTSORMIL Management Entity at:

INTSORMIL
113 Biochemistry Hall
University of Nebraska
Lincoln, Nebraska 68583-0748

Telephone: (402) 472-6032
Fax: (402) 472-7978
E-Mail: SRMLCRSP@unl.edu
<http://intsormil.org>

A Research Development Program of the Agency for International
Development, the Board for International Food and Agricultural
Development (BIFAD), Participating Land-Grant Universities, Host
Country Research Agencies and Private Donors

INTSORMIL INSTITUTIONS

Kansas State University
Mississippi State University
Ohio State University
Purdue University
Texas A&M University
University of Nebraska - Lincoln
USDA-ARS, Tifton, Georgia
West Texas A&M University

INTSORMIL Institutions are affirmative action/equal opportunity institutions.

INTSORMIL Management Entity

Dr. John M. Yohe, Program Director
Ms. Joan Frederick, Financial Officer
Ms. Kimberly Christiansen, Program Assistant
Ms. Diane Sullivan, Accounting Clerk

INTSORMIL Board of Directors

Dr. Forrest Chumley, Kansas State University
Dr. Frank Gilstrap, Texas A&M University
Dr. Bill Herndon, Jr., Mississippi State University
Dr. David Hansen, Ohio State University
Dr. James Lowenberg-Deboer, Purdue University
Dr. Gary Cunningham, University of Nebraska
Dr. Donald Topliff, West Texas A&M University
Dr. Noël Pallais Checa, INTA, Nicaragua

INTSORMIL Technical Committee

Dr. Gebisa Ejeta, Purdue University
Dr. Bruce Hamaker, Purdue University
Dr. Steve Mason, University of Nebraska
Dr. Bonnie Pendleton, West Texas A&M University
Dr. Gary Peterson, Texas A&M University
Dr. Lloyd Rooney, Texas A&M University
Dr. John Sanders, Purdue University
Dr. Mitchell Tuinstra, Kansas State University
Ing. René Clará, CENTA, El Salvador
Dr. Aboubacar Touré, IER, Mali
Dr. Hamis Sadaan, Ministry of Agriculture & Food Security, Tanzania
Dr. Medson Chisi, SMIP, Zambia

Contents

Introduction and Program Overview

Project Reports

Sustainable Plant Protection Systems

Agroecology and Biotechnology of Stalk Rot Pathogens of Sorghum and Millet John F. Leslie (KSU 210).....	3
Low Input Ecologically Defined Management Strategies for Insect Pests on Sorghum Henry N. Pitre (MSU 205).....	5
<i>Striga</i> Biotechnology Development and Technology Transfer Gebisa Ejeta (PRF 213)	7
Sustainable Management of Insect Pests Bonnie B. Pendleton (WTU 200).....	9

Sustainable Production Systems

Economic and Sustainability Evaluation of New Technologies in Sorghum and Millet Production in INTSORMIL Priority Countries John H. Sanders (PRF 205).....	13
Cropping Systems to Optimize Yield, Water and Nutrient Use Efficiency of Pearl Millet and Grain Sorghum Stephen C. Mason (UNL 213)	15
Soil and Water Management for Improving Sorghum Production in Eastern Africa Charles Wortmann and Martha Mamo (UNL 219)	17

Germplasm Enhancement and Conservation

Breeding Pearl Millet for Improved Stability, Performance, and Pest Resistance Jeffrey P. Wilson (ARS 206).....	21
Breeding Grain Mold Resistance in High Digestibility Sorghum Varieties Dirk Hays (TAM 230).....	23
Development and Enhancement of Sorghum Germplasm with Sustained Tolerance to Biotic and Abiotic Stress Gebisa Ejeta (PRF 207)	25
Enhancing the Utilization of Grain Sorghum and Pearl Millet through the Improvement of Grain Quality via Genetic and Nutritional Research Mitch Tuinstra, Joe Hancock, William Rooney and Clint Magill (KSU 220)	27
Germplasm Enhancement for Resistance to Insects and Improved Efficiency for Sustainable Agriculture Systems Gary C. Peterson (TAM 223)	29

Crop Utilization and Marketing

An Evaluation of New Market Development and Marketing Strategies on Sorghum and Millet Farmers' Income in Tanzania and Zambia Donald Larson and J. Mark Erbaugh (OSU 200)	33
Chemical and Physical Aspects of Food and Nutritional Quality of Sorghum and Millet Bruce R. Hamaker (PRF 212).....	35
Food and Nutritional Quality of Sorghum and Millet Lloyd L. Rooney (TAM 226).....	37
Entrepreneurship and Product Development in East Africa: A Strategy to Promote Increased Use of Sorghum and Millet David S. Jackson (UNL 220)	41

Host Country Program Enhancement

Central America Stephen C. Mason	45
Horn of Africa Gebisa Ejeta	47
Southern Africa Gary C. Peterson	49
West Africa Bruce R. Hamaker	51

Educational Activities

Year 27 Educational Activities.....	55
Year 27 INTSORMIL Degree Participants	56
Year 27 INTSORMIL Non-Degree Participants	57

Appendices

INTSORMIL Sponsored and Co-Sponsored Workshops 1979-2006	61
Acronyms	63

Introduction and Program Review

The 2006 INTSORMIL Annual Report presents the progress and notable achievements by the Sorghum/Millet CRSP during the period of July 1, 2005 - June 30, 2006. These results are an outcome of partnerships between scientists at seven U.S. Land Grant Universities (Kansas State University, Mississippi State University, Ohio State University, University of Nebraska, Purdue University, Texas A&M University and West Texas A&M University), scientists of the Agricultural Research Service of the U.S. Department of Agriculture at Tifton, Georgia and the National Agricultural Research Systems (NARS) and National Universities in nineteen countries in Central America, West Africa, East Africa and Southern Africa.

Agricultural research provides benefits not only to producers but also to processors and consumers of agricultural products. Agricultural research has continuously shown that it is able to provide improved products of greater quantity and quality, as well as improved health to consumers and broad-based economic growth which goes beyond producers and consumers.

The Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP) conducts collaborative research using partnerships between 20 U.S. university scientists and scientists of the National Agricultural Research Systems (NARS), IARCs, PVOs and other CRSPs. INTSORMIL is programmatically organized for efficient and effective operation and captures most of the public research expertise on sorghum and pearl millet in the United States. The INTSORMIL mission is to use collaborative research as a mechanism to develop human and institutional research capabilities to overcome constraints to sorghum and millet production, marketing and utilization for the mutual benefit of the Less Developed Countries (LDCs) and the U.S. Collaborating scientists in NARS of collaborating developing countries and the U.S. jointly plan and execute research that mutually benefits all participating countries, including the United States.

INTSORMIL takes a regional approach to sorghum and millet research in western, eastern, and southern Africa, and in Central America. INTSORMIL focuses resources in the four regions supporting the general goals of building NARS institutional capabilities, creating human and technological capital to solve problems constraining sorghum and millet production, marketing and utilization. INTSORMIL's activities are aimed at achieving sustainable, global impact, promoting economic growth, enhancing food security, and encouraging entrepreneurial activities.

INTSORMIL continues to contribute to the transformation of sorghum and pearl millet from subsistence crops to value-added, cash crops. Because sorghum and millet are important food crops in moisture-stressed regions of the world, they are staple crops for millions in Africa and Asia. In their area of adaptation, sorghum and millet have a distinctly competitive advantage to yield more grain than other cereals. The development of both open-pollinated and hybrid sorghums for food and feed with improved properties such as increased digestibility and reduced tannin content is contributing to sorghum becoming a major feed grain in the U.S., Africa and Central and South America. Pearl millet is also becoming an important feed source for poultry in the southeastern United

States. Improved varieties and hybrids of pearl millet, and improved lines of sorghum can be grown in developing countries, as well as the United States. They have great potential for processing into high-value food products which can be sold in villages and urban markets, where they compete successfully with imported wheat and rice products. In the U.S. pearl millet is sold in niche markets, i.e., heads of pearl millet for bird food and for floral arrangements. These emerging markets for sorghum and pearl millet are results of the training and collaborative international scientific research that INTSORMIL has supported both in the United States and collaborating countries.

Although significant advances have been made in the improvement and production of sorghum and millet in the developing countries of regions in which INTSORMIL serves, population growth continues to exceed rates of increase in cereal production capacity. There remains an urgent need to continue the momentum of our successes in crop improvement, improved processing and marketing of sorghum and millet, and strengthening the capabilities of NARS scientists to conduct research on constraints to production, utilization and marketing of sorghum and millet.

The INTSORMIL program maintains a flexible approach to accomplishing its mission. The success of INTSORMIL can be attributed to the following strategies which guide the program in its research and linkages with technology transfer entities.

Developing institutional and human capital: INTSORMIL provides needed support for education of agricultural scientists in both developing countries and the United States. The results of this support include strengthening the capabilities of institutions to conduct research on sorghum and millet, development of international collaborative research networks, promoting and linking to technology transfer activities and dissemination of technologies developed from research, and enhancing national, regional, and global communication linkages. INTSORMIL provides essential support to bridge gaps between developing countries and the United States. A major innovative aspect of the INTSORMIL program is to maintain continuing relationships with scientists of collaborating countries upon return to their research posts in their countries. They become members of research teams with INTSORMIL and NARS scientists who conduct research on applications of existing technology and development of new technology. This integrated relationship prepares them for leadership roles in their national agricultural research systems and regional networks in which they collaborate.

Conserving biodiversity and natural resources: Results of the collaborative research supported by INTSORMIL include development and release of enhanced germplasm, development and improvement of sustainable production systems and development of sustainable technologies to conserve biodiversity and natural resources. The knowledge and technologies generated by INTSORMIL research also enhance society's quality of life and enlarge the range of agricultural and environmental choices available both in developing countries and the United States. INTSORMIL promotes conserving millet and sorghum germplasm, conserving natural control of arthropod pests and diseases of sorghum and

millet, developing resource-efficient cropping systems, developing integrated pest management strategies, developing cultivars with improved nutrient and water use efficiencies, and evaluating impacts of sorghum/millet technologies on natural resources and biodiversity.

Developing research systems: Collaboration in the regional sites in countries other than the United States has been strengthened by using multi-disciplinary research teams composed of American and NARS scientists focused on unified plans to achieve common objectives. INTSORMIL scientists provide global leadership in biotechnology research on sorghum and pearl millet. The outputs from these disciplinary areas of research are linked to immediate results. INTSORMIL uses both traditional science of proven value and newer disciplines such as molecular biology in an integrated approach to provide products of research with economic potential. These research products which alleviate constraints to production and utilization of sorghum and pearl millet are key elements in fighting hunger and poverty by providing means for economic growth, generation of wealth, and improved health. New technologies developed by INTSORMIL collaborative research are extended to farmers' fields and to processors and marketers of sorghum and millet products in developing countries and the United States through partnerships with NGOs, research networks, extension services and the private sector. In addition, economic analysis by INTSORMIL researchers plays a crucial role in enabling economic policymakers to more intelligently consider policy options to help increase the benefits and competitiveness of sorghum and pearl millet as basic food staples and as components of value-added products.

Supporting information networking: INTSORMIL research emphasizes working with both national agricultural research systems and sorghum and millet networks to promote effective technology transfer from research sites within the region to local and regional institutions. Technology transfer is strengthened by continued links with regional networks, International Agricultural Research Centers, and local and regional institutions. Emphasis is placed on strong linkages with extension services, agricultural production schemes, private and public seed programs, agricultural product supply businesses, and nonprofit organizations, such as NGOs and PVOs, for efficient transfer of INTSORMIL-generated technologies. Each linkage is vital to development, transfer, and adoption of new production and utilization technologies, with the ultimate goal being economic and physical well-being to those involved in production and utilization of these two important cereals both in developing countries and the United States.

Promoting demand-driven processes: INTSORMIL economic analyses are all driven by the need for stable markets for the LDC farmer and processor, so these analyses focus on prioritization of research, farm-level industry evaluation, development of sustainable food technology, processing, and marketing systems. INTSORMIL seeks alternate food uses and new processing technologies to save labor and time required in preparation of sorghum/millet for food and feed, and add value to the grain and fodder of the two crops. Research products transferred to the farm, to the livestock industry, and to processors and marketers of sorghum and millet are aimed at spurring rural and urban economic growth and providing direct economic benefits to producers and consum-

ers. INTSORMIL assesses consumption shifts and socioeconomic policies to reduce effects of price collapses, and conducts research to improve processing for improved products of sorghum and millet which are attractive and useful to the consumer. Research by INTSORMIL agricultural economists and food scientists seeks to reduce effects of price collapse in high yield years, and to create new income opportunities through diversification of markets for sorghum and pearl millet. INTSORMIL socioeconomic projects measure impact and diffusion and evaluate constraints to rapid distribution and adoption of introduced, new technologies.

The INTSORMIL program addresses the continuing need for development of technologies for agricultural production, processing and utilization of sorghum and pearl millet for both the developing world, especially in the semiarid tropics, and the United States. There is international recognition by the world donor community that National Agricultural Research Systems (NARS) in developing countries must assume ownership of their development problems and move toward achieving resolution of them. The INTSORMIL program is a proven model that empowers the NARS to develop the capacity to assume ownership of their development strategies, while at the same time resulting in significant benefits to the U.S. agricultural sector. These aspects of INTSORMIL present a win-win situation for international agricultural development, strengthening developing countries' abilities to solve their problems in the agricultural sector while providing benefits to the United States.

Administration and Management

The University of Nebraska (UNL) hosts the Management Entity (ME) for the Sorghum/Millet CRSP and is the primary grantee of USAID. UNL subgrants are made to the participating U.S. universities and USDA/ARS for research projects between U.S. scientists and their collaborating country counterparts. A portion of the project funds managed by the ME and U.S. participating institutions, supports regional research activities. The Board of Directors (BOD) of the CRSP serves as the top management/policy body for the CRSP. The Technical Committee (TC), External Evaluation Panel (EEP) and USAID personnel advise and guide the ME and the Board in areas of policy, technical aspects, collaborating country coordination, budget management, and review.

Education

During Year 27, 2005-2006, there were 38 students from 16 different countries enrolled in an INTSORMIL advanced degree program and advised by an INTSORMIL principal investigator. Approximately 71% of these students came from countries other than the U.S. The number of students receiving 100% funding by INTSORMIL in 2006-2006 totaled nine. An additional 28 students received partial funding from INTSORMIL and the remaining student was funded from inter-CRSP activities. INTSORMIL places high priority on training of women. In 2005-2006, 32% of all INTSORMIL graduate participants were female.

Another important category of education which INTSORMIL supports is non-degree research activities, namely postdoctoral research and research of visiting scientists with INTSORMIL PIs in the United States. During Year 27, 13 scientists improved their

education as either postdoctoral scientists (2) or visiting scientists (11). Their research activities were in the disciplines of agronomy, food science and animal nutrition, entomology, molecular biology, and pathology. These scientists came to the United States as post-doctoral scientists or visiting scientists from Brazil, El Salvador, Egypt, Ethiopia, Ghana, Guatemala, Mali, Nicaragua, Niger and Uganda. In addition to non-degree research activities there were 808 participants (482 male and 326 female) who were supported by INTSORMIL for participation in workshops and conferences.

Networking

The Sorghum/Millet CRSP global plan for collaborative research includes workshops and other networking activities such as newsletters, publications, exchange of scientists, and exchange of germplasm. The INTSORMIL global plan is designed for research coordination and networking within ecogeographic zones and, where relevant, between zones. The Global Plan:

- Promotes networking with IARCs, NGO/PVOs, regional networks (ASARECA, ECARSAM, and others) private industry and government extension programs to coordinate research and technology transfer efforts.
- Supports INTSORMIL participation in regional research networks to promote professional activities of NARS scientists, to facilitate regional research activities (such as multi-location testing of breeding materials), promotes germplasm and information exchange, and facilitates impact evaluation of new technologies.
- Develop regional research networks, short-term and degree training plans for sorghum and pearl millet scientists.

Established networking activities have been accomplished with ICRISAT in India, Mali, Niger, Central America and Zimbabwe, SAFGRAD, WCASRN/ROCARS, WCAMRN/ROCAFREMI, ASARECA, ECARSAM and SMIP/SMINET in Africa, CLAIS and CIAT of Central and South America and SICNA and the U.S. National Grain Sorghum Producers Association for the purpose of coordinating research activities to avoid duplication of effort and to promote the most effective expenditures of research dollars. There also has been efficient collaboration with each of these programs in co-sponsoring workshops and conferences, and for coordination of research and long-term training. INTSORMIL currently cooperates with ICRISAT programs in east, southern and west Africa. Since 2004 INTSORMIL has been executing a Marketing-Processing Project funded by the USAID West Africa Regional Program (WARP) which focuses on responding to emerging market demand with improvements in the supply of consistent quality grain of sorghum and pearl millet. Initial activities (2002-2004 supported by INTSORMIL) were on making contracts between farmers' groups and the rapidly growing sector of millet food processors (couscous, arraw, degue, sankal, tchakri, and yogurt with tchakri) in four countries of the Sahel (Senegal, Mali, Burkina Faso, and Niger). INTSORMIL will continue to promote free exchange of germplasm, technical information, improved technology, and research techniques.

Regional Activities and Benefits

West Africa

(Burkina Faso, Ghana, Mali, Niger, Nigeria, Senegal)

The West Africa Regional Program now encompasses six countries of the Sahelian region – Burkina Faso, Ghana, Mali, Niger, Nigeria, and Senegal. During this year on-farm testing, field tours, and farm days were organized for maximal exchange with other farmers and to promote acceptance of improved cultivars by farmers. On-farm testing included on-farm evaluation of soil fertility management options for millet yield increases including use of poultry manure and microdose fertilizer applications. Improved elite sorghum hybrids, insect and Striga resistant lines were evaluated on-farm. Countrywide evaluation and demonstration of the marketing potential for value-added sorghum and millet products including poultry feed was accomplished. This is strengthening the linkages between production and utilization activities.

Horn of Africa

(Ethiopia, Eritrea, Kenya, Tanzania, Uganda)

Ongoing collaborative research has progressed in each of the countries. However, activities were terminated in Eritrea in late 2005. Host country PIs in each country have taken keen interest in collaborating with U.S. PIs where partnerships have been developed. Because of expanded collaborative involvement in several countries in the Horn of Africa Region more U.S. PIs are needed to provide collaborative linkages with host country scientists. Sorghum breeding efforts in Ethiopia have particularly gone well. Work on development and evaluation of experimental sorghum hybrids have resulted in identification of elite hybrids with potential for wide cultivation in lowland areas of the country. Efforts on Striga control have focused on regional testing of an integrated package of technologies that included tied-ridging as a water conservation measure, nitrogen fertilization, and resistant sorghum cultivars. This activity is managed and implemented as a pilot project with supplemental funding from the Office of Foreign Disaster Assistance (OFDA) of USAID. Striga resistant sorghum varieties have been officially released for wide cultivation and the integrated Striga management pilot project has aroused interest in the technology and a community based seed multiplication effort has been started.

Southern Africa

(Botswana, Mozambique, Namibia, South Africa, Zambia)

The overall emphasis of INTSORMIL in Southern Africa is to shift sorghum and pearl millet from subsistence crops to value-added cash crops and complete the graduate training of students supported through the project. The Southern Africa Regional program is a multi-disciplinary program with the goal to understand the factors that reduce grain yield and quality of sorghum and pearl millet, to develop technology to mitigate the stress effect, and to develop end-use processing technology that will increase production and processing yield of high quality sorghum and pearl millet grain. INTSORMIL funding provides resources to support graduate training and technology transfer activities conducted in col-

laboration with the National Agricultural Research Programs in the areas of:

- Food Quality
- Pathology
- Entomology
- Mycotoxin Research
- Economics
- Breeding

There are two major constraints to development of the South Africa regional program at this time. First is the lack of scientific expertise for sorghum and pearl millet in the region. Within each institution and discipline there is basically one scientist available for collaboration. This is contributing to the increasing emphasis of regional scientists collaborating across national boundaries. As capable students are identified and matched with available advisors additional graduate education will occur. The students need assurance of positions in sorghum and pearl millet research upon returning from their degree programs. The second constraint is the continued decline in the number of hectares devoted to sorghum (and pearl millet) production. As in most semiarid regions the decline can be attributed to government policy, lack of a marketing system to handle either traditional grain or grain with enhanced end-use traits, and consumer preference for other grains. These problems can also work to the benefit of sorghum and pearl millet if a production and marketing system can be developed for the crops. With the right varieties or hybrids and the right marketing system the natural stress resistance of sorghum and pearl millet can help provide a consistent supply of high quality grain for processors and consumers.

Central America (El Salvador, Nicaragua, Honduras)

On the whole, the present collaborative model being used by the Central America Regional Program is functioning well, due to the commitment of scientists in the region, and has resulted in transfer of improved cultivars with increased yield and nitrogen use efficiency. Grain utilization issues are increasing in importance in the program. Researchers participating in the INTSORMIL Central America Regional Program have also developed management strategies for fall armyworm and sorghum midge, identified priority disease problems, developed sorghum flour substitution technology, and implemented research on nitrogen rates and nitrogen use efficiency of sorghum germplasm adapted to the region. Improved germplasm, production practices and pest management methods are being moved to producers through validation and demonstration trials, collaboration with extension services and NGOs, and through workshops with producers. Major progress was made in developing forage and grain varieties/hybrids, including line identification, testing and in seed production. A forage sorghum hybrid was released in El Salvador and Nicaragua in November 2005. Several grain sorghum varieties/hybrids were validated in 2005, with the best ones being released in 2006.

Future Directions

During the past 27 years, INTSORMIL has educated more than one thousand scientists in degree programs, visiting scientist

experiences, postdoctoral training, workshops, and conferences. About one-third of those trained are from the U.S. and two-thirds are from developing countries. The bridges built by this training are crucial to maintain scientific and peaceful linkages between the United States and developing countries. The collaborative research supported by INTSORMIL continues to produce benefits for both developing countries and the United States. Food production, utilization and marketing in both developing countries and the United States are strengthened by INTSORMIL. The health benefits of the two nutritious cereals, sorghum and millet, are enjoyed by millions of people. Sorghum is a significant element in the food chain of the United States, being a key feed for livestock. What, then is the future for collaborative, international sorghum and millet research supported by INTSORMIL? The future is bright.

There continues to be a need for highly qualified researchers for these two crops both in developing countries and the United States. INTSORMIL fulfills a unique role in providing postgraduate training (M.S. and Ph.D. level) to meet this need. As the demand for water in cities continues to put greater pressure on the use of water for irrigated crop production, sorghum and millet which are, for the most part, rainfed will gain increased importance in meeting the caloric needs of developing countries, particularly in the semiarid tropics, and the livestock feed industry in the United States. Recent INTSORMIL research on the nutritional benefits of sorghum and millet form a strong base for future research to enable the commercialization of nutritionally superior sorghum. Based on its achievements, the INTSORMIL team is well positioned to contribute even more effectively to ending hunger and raising incomes. With increasing strength of scientific expertise in developing countries, INTSORMIL is now able to more effectively reduce constraints to production and utilization of sorghum and millet to the mutual benefit of developing countries and the United States. Advances in sorghum and millet research over INTSORMIL's first 27 years and the training of sorghum and millet scientists by INTSORMIL in the United States, Africa and Central America now enable scientists from developing countries and the United States to jointly plan and execute mutually beneficial collaborative research. These collaborative relationships are key to INTSORMIL's success and will continue as fundamental approaches to meeting the INTSORMIL mission. In the future, INTSORMIL will target NARS collaborative ties that reflect regional needs for sorghum and/or millet production. These ties are in the sorghum and millet agroecological zones of western, eastern, and southern Africa, and Central America. By concentrating collaboration in selected sites, INTSORMIL optimizes its resources, builds a finite scientific capability on sorghum and millet, and creates technological and human capital that has a sustainable and global impact.

Future strategies will maintain INTSORMIL's current, highly productive momentum, build on its record of success, and accomplish a new set of goals. INTSORMIL's global strategy is intended to contribute to the shift of sorghum and pearl millet from subsistence crops to value-added, cash crops, and proposes to produce scientific knowledge and technologies to contribute to economic growth, improve nutrition, increase yield, and improve institutional capability to meet global, regional and national needs.

Sustainable Plant Protection Systems



Agroecology and Biotechnology of Stalk Rot Pathogens of Sorghum and Millet

**Project KSU 210
John F. Leslie
Kansas State University**

Principal Investigator

John F. Leslie, Dept. of Plant Pathology, Kansas State University, Manhattan, Kansas 66506-5502

Collaborating Scientists

Dr. Ranajit Bandyopadhyay, International Institute for Tropical Agriculture, Ibadan, Nigeria
Dr. Elhamy El-Assiuty, Plant Pathology Research Institute, Agricultural Research Center, Giza, Egypt
Dr. J. Peter Esele, Serere Agricultural and Animal Production Research Institute, NARO, Soroti, Uganda
Dr. Walter F. O. Marasas, PROMEC, South African Medical Research Council, Tygerberg, South Africa
Dr. Neal McLaren, University of the Free State, Bloemfontein, South Africa
Drs. L. E. Claflin, & D. J. Jardine, Dept. of Plant Pathology, Kansas State University, Manhattan, Kansas 66506
Dr. J. S. Smith, Dept. of Animal Sciences & Industry, Kansas State University, Manhattan, Kansas 66506
Dr. R. L. Bowden, USDA-ARS Plant Science & Entomology Research Unit, Manhattan, Kansas 66506
Dr. A. E. Desjardins, Mycotoxins Unit, National Center for Ag Utilization research, USDA-ARS, Peoria, Illinois 61601

The analysis of Fusarium toxins as a complement to aflatoxin analyses in maize and sorghum is critical to the production of food quality grains and thus the fight against poverty and hunger. Problems associated with toxins in contaminated maize may make maize produced in marginal areas unsafe for human consumption with levels of toxins expected to be higher than those allowed even in animal feed in developed countries. The results of this work on analysis of Fusarium Toxins in sorghum and confirmation that sorghum has less mycotoxins than maize could significantly boost sorghum production in areas where Fusarium in maize is a problem. The extension will also provide for the completion of the “Fusarium Laboratory Workshop” and “Scientific Writing” training workshops as scheduled. Both are critical activities.

Low Input Ecologically Defined Management Strategies for Insect Pests on Sorghum

Project MSU 205
Henry N. Pitre
Mississippi State University

Principal Investigator

Henry N. Pitre, Entomologist/Professor, Mississippi State University, Box 9775, Mississippi State, MS 39762

Collaborating Scientists

Rafael Obando Solis, Agronomist, INTA, Apdo Postal 1247, Managua, Nicaragua
Carmen Gutierrez, Entomologist, INTA, Apdo Postal 1247, Managua, Nicaragua
Yanette Gutierrez, Plant Pathologist, UNA, Managua, Nicaragua
Martha Zamora, Entomologist, UNA, Managua, Nicaragua
Sergio Pichardo Guido, Plant Pathologist, UNA, Managua, Nicaragua
Francisco Varga, Agronomist, ANPROSOR, Managua, Nicaragua
René Clará, Sorghum Breeder, CENTA, Apdo Postal 885, San Salvador, El Salvador
Jaime Ayala Moran, Entomologist, CENTA, Apdo Postal 885, San Salvador, El Salvador
Leopoldo Cervantes, Entomologist, University of El Salvador, San Salvador, El Salvador
Reina Serrano, Plant Pathologist, CENTA, Apdo Postal 885, San Salvador, El Salvador
Mario Parada, Entomologist, CENTA, Apdo Postal 885, San Salvador, El Salvador
Larry Clafflin, Plant Pathologist, Kansas State Univ., Manhattan, KS 66506
Rich Baird, Plant Pathologist, Mississippi State University, Mississippi State, MS 39762

MSU-205 is working on the completion of two INTSORMIL Ph.D. programs at Mississippi State University and the completion of other sorghum research activities expected to have an immediate benefit to farmers in Central America and the United States. Timely Dipel and calcium sulfate sprays were more effective than chemical sprays for management of insect pests and diseases, respectively, on sorghum in Nicaragua. Grain feeding insect pests were identified in commercial seed storage facilities and were associated with levels of aflatoxin and related fungi, mostly *Fusarium* spp, but also four other fungi. In El Salvador, 16 lines of sorghum were identified with some resistance to a complex of diseases and insect pests. Timely application of selected insecticides at sorghum bloom proved to be relatively effective against the sorghum midge at moderate infestation levels. Whitefly population levels on sorghum and rice were documented at lowest levels during the past three years. Insect pests and diseases were quantified for the second year of a three year sorghum-soybean crop rotation study in Mississippi to determine the influence of this planting practice on these pests and yield. Pest insect and disease levels were about the same in 2005 as in 2004 in the various treatments. Stinkbug identification and population levels on crop and non-crop hosts in a sorghum date-of-planting study were documented, economic threshold studies were conducted, and crop host plant preferences were determined. Ecological and biological investigations of insect pests and diseases of sorghum, sorghum cropping systems investigations, and identification of economic threshold levels for specific pests will provide information for development of improved pest management tactics and strategies for sorghum crops in Central America

and the United States. Student training and crop production technology transfer assists in institution building activities and in improving crop production in host countries.

Publications

Presentations

10 presentations at scientific meetings (with proceedings).

Publications and Presentations

Proceedings

Gutierrez, Yanet, Martha Zamora, Roger Vilchez, Oliver Rugama and Henry Pitre. 2006. Calidad Fitosanitaria y Presencia de Aflatoxinas en Granos de Sorgo (*Sorghum bicolor* (L.) Moench). 52nd Cooperative Meeting to Improve Crop and Animal Production in Central America. (PCCMCA Meeting) April 24-28, 2006. Montelimar, Nicaragua.

Zamora, Martha, Yanet Gutierrez, Carmen Gutierrez, Sergio Soza, Guillermo Taleno and Henry Pitre. 2006. Evaluacion de Productos Quimicos y no Quimicos para el Manejo de Plagas del Sorgo (*Sorghum bicolor* (L.) Moench) en Masaya y Managua. PCCMCA Meeting. April 24-28, 2006. Montelimar, Nicaragua.

- Obando, Rafael, Carmen Gutierrez, Martha Zamora, Gary Peterson and Henry Pitre. 2006. Evaluation of Sorghum Lines for Resistance to Sorghum Midge, *Stenodiplosis sorghicola* (Coq.), on Sorghum in Nicaragua. PCCMCA Meeting April 24-28, 2006. Montelimar, Nicaragua.
- Serrano, Reina, Carlos Borja, Andreae Moran and Henry Pitre. 2006. Evaluacion de la Tolerancia y/o Resistencia a Enfermedades e Insectos en Viveros ADIN de Sorgo, en El Salvador, 2005. PCCMCA Meeting, April 24-28, 2006.
- Cervantes, Leopoldo, Reina Serrano, Carlos Borja, A. Moran Rivera, A. Lemus Menjivar and Henry Pitre. 2006. Plaga de Musca Blanca (*Aleurocybotus occiduus*) para Maicillo (*Sorghum bicolor*) y Arroz (Oriza sativa) en El Salvador, Central America: 2003-2005. PCCMCA Meeting. April 24-28, 2006. Montelimar, Nicaragua.
- Parada, Mario and Henry Pitre. 2006. Southern Green Stinkbug (*Nezara viridula*) Development and Behavior With Relationships to Crop Plants. PCCMCA Meeting. April 24-28, 2006. Montelimar, Nicaragua.
- Parada, Mario and Henry Pitre. 2006. Feeding Damage by Nymphs and Adults of Southern Green Stinkbugs (*Nezara viridula*) on Sorghum Panicles. PCCMCA Meeting. April 24-28, 2006. Montelimar, Nicaragua.
- Pichardo, Sergio, Rich Baird and Henry Pitre. 2006. Occurrence of Disease and Insect Pests in Select Sorghum and Soybean Rotations in Mississippi. PCCMCA Meeting. April 24-28, 2006. Montelimar, Nicaragua.
- Pichardo, Sergio, Rich Baird and Henry Pitre. 2006. Occurrence of Insect and Disease Pests in Select Sorghum and Soybean Rotations in Mississippi. Proc. Southern Soybean Disease Workers. March 8-9, 2006. Jackson, Tennessee.
- Pichardo, Sergio, Rich Baird and Henry Pitre. 2006. Occurrence of Insect and Disease Pests in Select Sorghum (*Sorghum bicolor* (Linn.) Moench) and soybean (*Glycine max* (L.) Merr.) Rotations in Mississippi. Mississippi State Agric. Pest Mgt. Assoc. Joint Conf. Feb. 28 - March 2, 2006. Stoneville, Mississippi.

Striga Biotechnology Development and Technology Transfer

**Project PRF 213
Gebisa Ejeta
Purdue University**

Principal Investigator

Dr. Gebisa Ejeta, Dept. of Agronomy, Purdue University, West Lafayette, IN 47907

Collaborating Scientists

Dr. Fasil Redda, Weed Scientist, EARO, Ethiopia

Dr. Tesfaye Tesso, Sorghum Breeder, EARO, Ethiopia

Dr. Issoufou Kapran, Sorghum Breeder, INRAN, Niger

Dr. Aboubacar Touré, Sorghum Breeder, IER, Mali

Dr. N'Diaga Cisse, Sorghum Breeder, INERA, Senegal

Dr. Asmelash Abraha, Plant Protection Officer, DARE, Eritrea

Mr. Christopher Umburu, Weed Scientist, KARI, Kenya

Mr. Elias Latayo, Agronomist, Tanzania

Dr. Mbwanga, Striga Specialist, Tanzania

A major effort of this project this past year has been graduate student expense support for Mr. Zenbaba Wordoffa, Ethiopia, and for operational expenses to complete his graduate degree research which is currently underway. This includes funds for specialty quarantine supplies, *Striga* seed, chemicals and materials which have been required for him to complete his research work. *Striga* is the major parasitic weed pest throughout Africa and its control is very critical for food deficit areas such as Ethiopia. The functioning of this lab is critical as it is the only approved lab in the U.S. to work with *Striga* seed.

Sustainable Management of Insect Pests

Project WTU 200
Bonnie B. Pendleton
West Texas A&M University

Principal Investigator

Bonnie B. Pendleton, Assistant Professor of IPM, Entomology, Div. of Agriculture, Box 60998, West Texas A&M Univ, Canyon,
TX 79016

Collaborating Scientists

Mr. Fernando M. Chitio – IIAM, P.O. Box 36, Nampula, Mozambique
Mr. Joaquim A. Mutaliano - IIAM, P.O. Box 36, Nampula, Mozambique
Dr. Johnnie van den Berg – North West University, Potchefstroom, South Africa
Dr. Hannalene du Plessis – ARC, Private Bag X1251, Potchefstroom, South Africa
Dr. D. C. Munthali – Private Bag 0027, Botswana College of Agriculture, Gaborone
Dr. Niamoye Yaro Diariso – IER/CRRA, B.P. 258, Bamako, Mali
Dr. Yacouba O. Doumbia - IER/CRRA, B.P. 258, Bamako, Mali
Mr. Mamadou N’Diaye - IER/CRRA, B.P., 258, Bamako, Mali
Mr. Hamé Abdou Kadi Kadi – INRAN, B.P. 429, Niamey, Niger
Dr. Gary C. Peterson – Texas A&M Ag Research and Extension Ctr, Route 3, Box 219, Lubbock, TX 79401
Dr. G. J. Michels, Jr. – Texas A&M Ag Research and Extension Ctr, 6500 Amarillo Blvd. West, Amarillo, TX 79106
Dr. Roxanne A. Bowling – Texas A&M Ag Research and Extension Ctr, 6500 Amarillo Blvd. West, Amarillo, TX 79106

Project WTU-200 currently supports three graduate students from Mali, India, and Ethiopia. The project is supporting graduate student research on determining causes of stored sorghum grain to maize weevils, relating amount and time of phytochrome to daily times of sorghum flowering and resistance to sorghum midge, and evaluating effect of temperature on corn leaf aphids on sorghum to be completed and reports and publications written. In addition to this work, the project is completing research and will publish the results on evaluation of alternative management practices (plant resistance and biological control) compared to the use of organophosphate and carbamate insecticides for controlling greenbugs in a sorghum-wheat cropping system in Texas and Kansas. Collaborative research with HC scientists will be completed on evaluation of pearl millet for resistance to millet head miner in Niger, sorghum lines for resistance to sorghum midge in Mali and Niger, and sorghum genotypes for resistance to sugarcane aphid, stalk borers and termites in Botswana, Mozambique and South Africa.

Publications

Journal Articles

Pendleton, Michael W., E. Ann Ellis, Fernando M. Chitio, and Bonnie B. Pendleton. 2005. Morphological differences in sorghum grains resistant to maize weevil, *Sitophilus zeamais*. *Texas Journal of Microscopy* 36: 47.
Sambaraju, Kishan R., and Bonnie B. Pendleton. 2005. Fitness of greenbug (Homoptera: Aphididae) on wild and cultivated grasses. *Southwestern Entomologist* 30: 155-160.

Books, Book Chapters and Proceedings

2005. Mosca Midge Deteccion Y Control. Brochure in Spanish. Midstates Ag Services, Inc.
Dante Belete, Tebkew, Bonnie B. Pendleton, and Lal K. Almas. 2006. Economic benefit of using a resistant sorghum hybrid to manage sorghum midge (Diptera: Cecidomyiidae). Pp. 7-8. In Proceedings of the 54th Annual Meeting of the Southwestern Branch of the Entomological Society of America and the Annual Meeting of the Society of Southwestern Entomologists, 27 February – 2 March 2006, Austin, Texas, U.S.

Dissertations and Theses

Traore, T. 2006. Distribution of greenbug (Hemiptera: Aphididae) biotypes and effect of photoperiod on fitness of greenbug biotypes on sorghum. M.S. thesis. West Texas A&M University, TX.

Abstracts

Abdou Kadi Kadi, H., and B. B. Pendleton. 2005. Evaluation of pearl millet for resistance to millet head miner in Niger. *International Sorghum and Millets Newsletter* 46: 115-116.
Abdou Kadi Kadi, H., I. Kapran, and B. B. Pendleton. 2005. Identification of sorghum genotypes resistant to sorghum midge in Niger. *International Sorghum and Millets Newsletter* 46: 57-59.
Pendleton, M. W., S. Vitha, E. A. Ellis, F. M. Chitio, and B. B. Pendleton. 2005. Morphology of sorghum grain in relation to

- resistance to maize weevil. *International Sorghum and Millets Newsletter* 46: 55-57.
- Yaro Diarisso, N., and B. B. Pendleton. 2005. Effectiveness of plant powder in controlling lesser grain borer in stored sorghum grain. *International Sorghum and Millets Newsletter* 46: 62-63.
- Yaro Diarisso, N., M. Diourté, and B. B. Pendleton. 2005. Use of local plants to control sorghum insect pests in the field. *International Sorghum and Millets Newsletter* 46: 60-62.
- Damte, T., B. B. Pendleton, L. K. Almas, and G. C. Peterson. 2006. Farm-level return on use of a sorghum midge (Diptera: Cecidomyiidae)-resistant sorghum hybrid. *International Sorghum and Millets Newsletter* 47.
- Presentations**
- Lal K. Almas, W. Arden Colette, and Bonnie B. Pendleton. Grain sorghum production and profitability in the Texas Panhandle. West Texas A&M University Cornette Library Faculty Research Poster Presentation, 6 April 2006, Canyon, Texas.
- Roxanne Bowling, Bonnie B. Pendleton, Robert Bowling, and Gerald J. Michels. Alternatives to organophosphates and carbamates for managing aphids in wheat and sorghum. Fifty-third Annual Meeting of the Entomological Society of America, 15-18 December 2005, Fort Lauderdale, Florida.
- Roxanne Bowling, Bonnie B. Pendleton, and Gerald Michels. Does aphid-resistant wheat affect the ability of convergent lady beetle larvae to control aphids? Fifty-fourth Annual Meeting of the Southwestern Branch of the Entomological Society of America and the Annual Meeting of the Society of Southwestern Entomologists, 27 February – 2 March 2006, Austin, Texas.
- Tebkew Damte Belete, Bonnie B. Pendleton, and Lal K. Almas. Economic benefit of using a resistant sorghum hybrid to manage sorghum midge (Diptera: Cecidomyiidae). Fifty-fourth Annual Meeting of the Southwestern Branch of the Entomological Society of America and the Annual Meeting of the Society of Southwestern Entomologists, 27 February – 2 March 2006, Austin, Texas.
- Bonnie Pendleton. Pest management, entomology, and arachnology education and research partners at West Texas. Invited Symposium presentation. Fifty-fourth Annual Meeting of the Southwestern Branch of the Entomological Society of America and the Annual Meeting of the Society of Southwestern Entomologists, 27 February – 2 March 2006, Austin, Texas.
- Bonnie Pendleton et al. Sustainable management of insect pests in Africa and the U.S. INTSORMIL West Africa Regional Meeting, 7-9 March 2006, Ouagadougou, Burkina Faso.
- Bonnie Pendleton, Fernando Chitio, Michael Pendleton, Ann Ellis, and Stan Vitha. Relationship between sorghum morphology and resistance to maize weevil. Entomology Science Conference, 26-28 October 2005, College Station, Texas.
- Bonnie B. Pendleton, Roy D. Parker, et al. Sorghum entomology research in Texas. Great Plains/Drought Symposium, 6-7 October 2005, Lubbock, Texas.
- Bonnie Pendleton and Tiecoura Traore. Effect of photoperiod on greenbug fecundity and longevity on sorghum. Entomology Science Conference, 26-28 October 2005, College Station, Texas.
- Michael W. Pendleton, E. Ann Ellis, Fernando M. Chitio, and Bonnie B. Pendleton. Comparison of morphology of sorghum grain to resistance to maize weevil (Coleoptera: Curculionidae). Microscopy and Microanalysis Conference, 31 July – 4 August 2005, Honolulu, Hawaii.
- Michael W. Pendleton, E. Ann Ellis, Fernando M. Chitio, and Bonnie B. Pendleton. Comparison of morphology of sorghum grain to resistance to maize weevil (Coleoptera: Curculionidae). Texas Society of Microscopy, 13-15 October 2005, San Antonio, Texas.
- Michael W. Pendleton, E. Ann Ellis, Fernando M. Chitio, and Bonnie B. Pendleton. Comparisons of morphology of sorghum grain to resistance to maize weevil (Coleoptera: Curculionidae). Fifty-third Annual Meeting of the Entomological Society of America, 15-18 December 2005, Fort Lauderdale, Florida.
- Tiecoura Traore, Bonnie B. Pendleton, and G. J. Michels, Jr. Effect of photoperiod on fitness of greenbug (Hemiptera: Aphididae) biotypes E and I on sorghum. Ag Program Conference, The Texas A&M University System, 9-11 January 2006, College Station, Texas.

Sustainable Production Systems



Economic and Sustainability Evaluation of New Technologies in Sorghum and Millet Production in INTSORMIL Priority Countries

**Project PRF 205
John Sanders
Purdue University**

Principal Investigator

John H. Sanders, Purdue University, Dept of Agricultural Economics, West Lafayette, IN 47907

Collaborators

Felix Baquedano, Apartado Postal 6149, Managua, Nicaragua
Tahirou Abdoulaye, INRAN, JCAR, ICRISAT, Sadore, Niger
Kidane Georgis, EARO, PO Box 2003, Addis Ababa, Ethiopia
Barry I. Shapiro, ICRISAT, Patancheru AP 502 324, Hyderabad, India
Jeffrey D. Vitale, Dept. of Ag Economics, Oklahoma State University, Stillwater, OK 74078
Nega Wubeneh, ILRI, BP 5689, Addis Ababa, Ethiopia
Botorou Ouendeba, formerly ICRISAT and INRAN, Niamey, Niger
Lloyd Rooney, Texas A&M University, Dept. of Soil and Crop Sciences, College Station, Texas 77843

The major activities during this year have been the completion of graduate student projects and the completion of field research to evaluate the impacts of the improved marketing strategies. There are two graduate students being supported by this project. One has been doing his field research in Tigray, Ethiopia on the introduction of the combination of new sorghum technologies and market sector reform. Ethiopia has been introducing floor prices for the cereals and farmer cooperatives during the last three years. Both benefit the farmer by enabling him to obtain higher prices. The cooperatives provide loans to farmers for their cereals at harvest time but the farmer or the farmers' organization can sell later after the price recovers. The cooperatives also provide farmer members with cheaper fertilizer via bulk purchases. Moreover, they have greater bargaining power than individual farmers for selling sorghum. We are evaluating the effects of these market reforms on technology introduction and farmers' incomes. This student is expected to finish his Ph.D. thesis in early 2007. The other student has been working on Inventory Credit for millet in Niger. He will be collaborating with the USAID regional program supported Marketing-Processing Project, which is facilitating the introduction of Inventory Credit and four other marketing reforms into three Sahelian countries, Niger, Mali, and Senegal. This field research evaluates the impacts of the improved marketing strategies on the more rapid introduction of new sorghum and millet technologies and gives research support to the USAID development project. This above regional development activity (the Marketing-Processing Project) is funded by the regional USAID office in Accra and managed by INTSORMIL. The results of the studies of both students will provide information needed by the governmental bodies in each country in making policy decisions.

Publications

Journal Article

Abdoulaye, Tahirou and John H. Sanders, "New technologies, marketing strategies and public policy for traditional food crops: Millet in Niger," *Agricultural Systems*, 90: 272-292

Book Chapter

Sanders, John H. and Barry Shapiro, 2006 "Policies and market development to accelerate technological change in the semiarid zones: A focus on Sub-Saharan Africa," in Payne et al (editors), *Dryland Agriculture*, 2nd Edition, Agronomy Monograph No. 23, American Society of Agronomy, Crop Science Society of Agronomy, Soil Science Society of Agronomy, Madison, Wisconsin, 879-900.

Extension Publications

Abdoulaye, Tahirou, John H. Sanders and Botorou Ouendeba, 2006, *Quelle Cereale pour les Aliments de Volaille in Afrique de l'Ouest: Sorgho ou Mais?* INTSORMIL, Bulletin No. 4, Lincoln, Nebraska. 24 pages
Also four country specific laminated two pages written from this bulletin for each of the countries. These were widely distributed in the four Sahelian countries (Niger, Burkina Faso, Mali, and Senegal).

Theses

Baquedano, F., 2005, "The economics of inventory credit in western Niger," unpublished MS thesis, Department of Agricultural Economics, Purdue University, West Lafayette, IN.

Yigezu, A. Y., 2005. "Technological and policy changes for improving farmers' welfare in the Amhara region (Ethiopia)," unpublished MS thesis, Department of Agricultural Economics, Purdue University, West Lafayette, IN.

Cropping Systems to Optimize Yield, Water and Nutrient Use Efficiency of Pearl Millet and Grain Sorghum

**Project UNL 213
Stephen C. Mason
University of Nebraska**

Principal Investigators

Dr. Stephen C. Mason, University of Nebraska, Dept. of Agronomy, Lincoln, NE 68583
Dr. Samba Traoré, Cinzana Research Station, IER, B.P. 214, Segou, Mali
Dr. Nouri Maman, INTARNA Research Station, B.P. 429, Maradi, Niger
Dr. Minamba Bagayoko, IER, Niono, Mali
Dr. Taonda Sibiri Jean Baptiste, INERA, Koudougou, Burkina Faso
Mr. Seyni Sirifi, INRAN, Kollo, Niger
Mr. Siebou Pale, INERA, Koudougou, Burkina Faso
Mr. Maximo Hernández Valle, CENTA, San Salvador, El Salvador
Mr. Orlando Téllez Obregón, INTA, Somoto, Nicaragua
Mr. Leonardo García Centeno, UNA, Managua, Nicaragua

Collaborating Scientists

Ing. René Clará Valencía, Central America Regional Coordinator, San Salvador, El Salvador
Dr. Bruce Hamaker, Food Scientist, Purdue University, West Lafayette, IN 47907
Dr. Jeff Wilson, Millet Breeder, USDA-ARS, Tifton, GA 31793
Dr. Issoufou Kapran, Sorghum Breeder, INRAN, Niamey, Niger
Dr. Charles Wortmann, Soil Scientist, University of Nebraska, Lincoln, NE 68583
Dr. Martha Mamo, Soil Scientist, University of Nebraska, Lincoln, NE 68583
Dr. David Jackson, Food Scientist, University of Nebraska, Lincoln, NE 68583
Boniface Bougouma, Food Scientist, IRSAT/DTA, Ouagadougou, Burkina Faso
Prof. R. Klein, Agronomist, West Central Res. & Ext. Center, Univ. of Nebraska, North Platte, NE 69101
Dr. Roger Elmore, Agronomist, University of Nebraska, Lincoln, NE 68583
Dr. Drew Lyon, Agronomist, Panhandle Res. & Ext. Center, Univ. of Nebraska, Scottsbluff, NE 69361
Dr. Alex Martin, Weed Scientist, University of Nebraska, Lincoln, NE 68583
Dr. Lloyd Rooney, Food Scientist, Texas A & M University, College Station, TX 77843
Ing. Vilma Ruth Calderon, Food Scientist, CENTA, San Salvador, El Salvador
Ing. Quirino Argueta Portillo, Soil Scientist, CENTA, San Salvador, El Salvador
Ing. Rafael Obando Solis, Plant Breeder, CNIA/INTA, Managua, Nicaragua
Mr. Nanga Mady Kaye, Agronomist, Moundou, Chad
Dr. Gerrit Hoogenboom, Agronomist, University of Georgia (SANREM) CRSP

Accomplishments 2005 - 2006

West Africa

Research on-station and on-farm documented grain and stover yield increases of 250 to 300 kg ha⁻¹ grain and 700 to 2000 kg ha⁻¹ stover of pearl millet and grain sorghum from microdose fertilizer application in Burkina Faso, Mali and Niger. Technology transfer is on-going.

Research on-station and on-farm on different soil types across Burkina Faso documented an animal traction zai produced similar yields to traditional zai systems, but with 278 man-hours less labor per ha. Technology transfer is on-going.

On-station crop residue management research in Mali from the 1990's has been transferred to producers in surrounding villages. Survey's report that 70% of producers have adopted leaving all or part of crop residues on the soil surface, or incorporating into the soil.

Enhanced national scientific capability has been accomplished by completing two M.S. and one Ph.D. student programs for scientists from the region.

Contributed to knowledge about West African pearl millet cropping systems through publication of three scientific journal articles.

Central America

UNL-213 has identified 85-SCP-805 as a superior photoperiod sensitive sorghum variety for production in association with maize. This variety has high grain yield, high nitrogen use efficiency and high responsiveness to nitrogen fertilizer application. Seed production has been promoted with farmers (artesanal system) and transferred across El Salvador, and is now starting in Honduras. An economic impact study is presently being conducted in El Salvador.

UNL-213 has completed on-farm evaluation of two forage hybrids and the dual use variety CENTA S-3 that increase milk and meat production. These cultivars have been released in El Salvador and Nicaragua

This project has contributed to national program scientific capability by assisting with workshops sorghum grain and forage utilization. Over 100 persons participated in each of these workshops.

UNL-213 has enhanced Nicaragua scientific capability through short-term training of one scientist, and supervising 26 undergraduate theses with research conducted on sorghum.

This project has contributed to knowledge about sorghum cropping systems through publication of two scientific journal articles and five oral papers at PCCMCA meetings.

Nebraska

UNL-213 developed a production practice package for grain pearl millet production in Nebraska, includes planting date, seeding rate, row spacing, weed control and N fertilizer management.

Research documented the effects of nitrogen and crop rotation on sorghum grain quality, and the interrelationship of biological nitrogen fixation, soil nitrogen transformations and other factors involved in enhancing grain yield by using crop rotation with soybean.

The project has enhanced U.S. scientific capability by completing two M.S. students, and incorporating research results into crop management courses taught at the University of Nebraska. It has enhanced the knowledge of sorghum/pearl millet cropping systems in the U.S. through publication of 9 scientific articles.

Publications

Maman, N., S.C. Mason and D.J. Lyon. 2006. Nitrogen rate influence on pearl millet yield, N uptake and use efficiency in Nebraska. *Comm. Soil Sci. Plant Analysis* 37: 127 - 141.

Casteneda, J.W., S.C. Mason, Q. Argueta and R. Ventura. 2006. Nitrogen response and use efficiency of photoperiod-sensitive sorghum varieties in El Salvador. *Agronomia Mesoamericana* 17(2): 19 - 25.

Kaye, N.M., S.C. Mason, D.S. Jackson and T.D. Galusha. 2006. Crop rotation and soil amendment influence alters sorghum grain quality. *Crop Sci.* 46: (In Press).

Kaye, N.M., S.C. Mason and T.D. Galusha. 2006. Nodulating and non-nodulating soybean rotation influence on soil NO₃-N and water, and sorghum grain yield. *Agron. J.* 98: (In Press)

Garcia Centeno, L., O. Tellez and S.C. Mason. 2006. Uso eficiente del nitrogeno por 16 lineas de sorgo en Nicaragua. *Agronomia Mesoamericana* (Submitted)

Garcia Centeno, and S.C. Mason. 2006. Incorporacion del mungo como fuente de nitrogeno para produccion de sorgo. *La Calera* (Submitted)

Tojo Soler, C.M., N. Maman, X. Zhang, S.C. Mason and G. Hoogenboom. Determining optimum planting dates for pearl millet for two contrasting environments using a modeling approach. *Agric. Systems* (Submitted).

Soil and Water Management for Improving Sorghum Production in Eastern Africa

Project UNL 219

Charles Wortmann and Martha Mamo
University of Nebraska

Principal Investigators

Charles Wortmann & Martha Mamo, Dept. of Agronomy & Horticulture, Univ of Nebraska, Lincoln, NE 68583-0915

Collaborating Scientists

Gebisa Ejeta, Purdue Univ., Department of Agronomy, Purdue University, Lilly Bldg State Street, West Lafayette IN 47907-1150.
Steve Mason, University of Nebraska, Department of Agronomy and Horticulture, 279 Plant Science, Lincoln, NE 68583-0915
Kidane Georgis- EARO-Addis Ababa, P.O. Box 2003, Addis Ababa, Ethiopia.

Amare Belay and Gebreyesus Brhane, Mekelle Agricultural Research Center, P.O. Box 492, Mekelle, Ethiopia

Girma Abebe and Tewodros Mesfin, EARO-Melkassa, Nazareth Agricultural Research Center, P.O.Box 436, Nazareth, Ethiopia

Kaizzi Kayuki, KARI-NARO, P.O. Box 7061, Kampala, Uganda.

Soares Xerinda, INIA, Av. das FPLM, POBox 3658, Maputo, Mozambique

Summary

The purpose of this project is to promote economic growth, improve nutrition and increase yield. Opportunities to increase yield or to reduce production costs have been identified while promising research is continuing and technology dissemination activities have been initiated. Following verification and fine-tuning of the targeting of tied-ridge tillage for semi-arid areas of Ethiopia, extension efforts have been initiated while other aspects of tie-ridge technology are under investigation. Four opportunities for low-input management of soil fertility in semi-arid eastern Uganda have been verified as economical using farmer participatory approaches; information dissemination is underway and more detailed research has been initiated to assess the sustainability of these practices. Research on tillage alternatives commenced in 2005 in Tanzania. The study of some effects of occasional tillage for no-till systems has been completed while investigation of other aspects continues. Skip row planting as a means to reduce the effects of water deficits on yield is being investigated at three locations in Ethiopia and five locations in Nebraska.

Improved institutional capacity. A researcher, Gebreyesus Brhane, who completed his MS degrees at Alemaya University with support from UNL 219, and Dr. Kaizzi Kayuki came to UNL as visiting scientists. The research of a US and two international graduate students who have completed their degrees was supported by this project. An atlas of sorghum production in eastern Africa that is now being published is expected to improve institutional capacity by providing information useful for national and regional planning.

Publications and Presentations

Journal Articles

Brhane, G., C.S. Wortmann, M. Mamo, H. Gebrekidan, and A. Belay.

2006. Micro-basin tillage for grain sorghum production in semi-arid areas of northern Ethiopia. *Agronomy Journal* 98:124-128.

Wortmann, C.S., S.A. Xerinda, M. Mamo and C.A. Shapiro. 2006. No-till row crop response to starter fertilizer in eastern Nebraska: I. irrigated and rainfed corn. *Agronomy Journal* 98:156-162.

Wortmann, C.S., S.A. Xerinda, and M. Mamo. 2006. No-till row crop response to starter fertilizer in eastern Nebraska: II. rainfed grain sorghum. *Agronomy Journal*. 98: 187-193.

Dissertations and Theses

Garcia, Juan Pablo, 2005. The effects of occasional tillage in no-till systems on nutrient distribution and uptake and on vesicular arbuscular mycorrhizal (VAM) colonization. MS thesis, Dep. of Agronomy and Horticulture, University of Nebraska-Lincoln.

Miller, Gregory G., 2006. Sorghum and mycorrhizal responses to liming strategies in pH stratified soil. MS thesis, Dep. of Agronomy and Horticulture, University of Nebraska-Lincoln.

Quincke, J. Andres. 2006. Occasional tillage or no-till systems to improve carbon sequestration, and soil physical and microbial properties. PhD dissertation, Dep. of Agronomy and Horticulture, University of Nebraska-Lincoln.

Abstracts

Occasional Tillage of No-Till Systems: Water Infiltration and Runoff Assessment with a Portable Rainfall Simulator. Charles S. Wortmann, Martha Mamo, Juan A. Quincke. American Society of Agronomy.

Occasional Tillage of No-Till Systems: Vertical Distribution of Labile Soil Carbon Pools. Juan A. Quincke, Martha Mamo, Charles S.Wortmann. American Society of Agronomy.

A Decision Guide for Tied-Ridging in Semi-Arid Areas of Ethiopia. M. Gebreyesus Brhane, Tewodros Mesfin, Amare Belay, Martha Mamo, Charles S.Wortmann. American Society of Agronomy.

Roles for Herbaceous and Grain Legumes, Kraal Manure and Inorganic Fertilizer for Soil Fertility Management in East-

ern Uganda. Kayuki C. Kaizzi, John Byalebeka, Charles S.Wortmann, Martha Mamo. American Society of Agronomy.

Occasional Tillage in No-Till Systems: Soil Phosphorus Distribution and Crop Uptake. Juan Pablo Garcia, Charles S.Wortmann, Martha Mamo. American Society of Agronomy.

Germplasm Enhancement and Conservation



Breeding Pearl Millet for Improved Stability, Performance, and Pest Resistance

Project ARS 206
Jeffrey P. Wilson
USDA-ARS

Principal Investigator

Jeffrey P. Wilson, USDA-ARS Crop Genetics and Breeding Research Unit, University of Georgia, Tifton, GA 31793-0748

Collaborating Scientists

Issaka Ahmadou, INRAN, B.P. 429, Niamey, Niger

Ignatius Angarawai, Lake Chad Research Institute, KM 6 Gamboru Ngala Rd., P.M.B. 1293, Maiduguri, Nigeria

Amadou Fofana, CRZ, Institut Senegalais de Recherches Agricoles, BP 53, Kolda, Senegal

Ferdinand Muuka, Kaoma Research Station, PO Box 940084, Kaoma, Zambia

Steven Nutsugah, Savannah Agricultural Research Institute, P.O. Box 52, Tamale, Ghana

Moussa Sanogo, IER, Cinzana Agricultural Research Station, BP 214, Ségou, Mali

Hamidou Traore, INERA, CREA de Kamboinse, B.P. 476, Ouagadougou, Burkina Faso

Scott Bean, USDA-ARS Grain Marketing and Production Research Center, Manhattan, KS 66502

Donghai Wang, Department of Biological and Agricultural Engineering, Kansas State University, Manhattan KS 66506

John McKinney, Identity Preserved Grain Laboratory, Illinois Crop Improvement Association, Champaign, IL 61826

Andrew J. McAloon, Crop Conversion Science and Engineering Research Unit, USDA-ARS, Wyndmoor, PA 19038-8595

Nick Dale, Department of Poultry Science, University of Georgia, Athens, GA 30602-2772

Only critical research and technology transfer activities expected to have a high impact have been conducted. This year the project is working on completion of an important study on the identification of African pearl millet cultivars with superior general and specific combining ability for producing new cultivars. A diallel population developed from cultivars with superior yield across and within countries will be distributed for planting in Senegal, Ghana, Burkina Faso, Mali, Niger, Nigeria, Botswana and Zambia. These replicated trials are being evaluated for grain yield, maturity, and resistance to diseases and pests, including downy mildew and Striga. The P.I. is visiting Niger, Mali, and Burkina Faso in West Africa, and Botswana and Zambia in Southern Africa to monitor trials. The results will be used to direct population development and selection of superior parents by host country scientists for crosses with regionally adapted germplasms across the in-country programs.

Downy mildew disease, root knot nematodes and the parasitic weed, *Striga* spp are major constraints to production in the region. Inbred breeding lines with root knot nematode resistance, developed from four diverse African pearl millets, are being evaluated for yield and resistance to downy mildew and *Striga* in Senegal, Ghana, Burkina Faso, Mali, Niger, Nigeria, Botswana and Zambia. The results will be specific inbred parents with superior performance in African settings that will be identified to advance inbreds with cytoplasmic male sterility, and with fertility restorer capability necessary for hybrid seed production.

This year's work is allowing completion of the identification of superior pearl millet grain hybrids for the U.S. Work completed includes evaluating eight new experimental pearl millet hybrids produced during the 2005-2006 winter season for grain yield and agronomic characteristics. Evaluations will be conducted at Moultrie, Plains, Watkinsville, and Newton GA. Field days will be held at Moultrie and Newton. Invitees will include growers, grain brokers, bobwhite quail producers, wildlife managers, and poultry industry representatives. This final test will be used to support release of a new experimental hybrid for the southern U.S. Field days will be used to educate the agribusiness community on existing market opportunities and to view new production and hybrid technologies.

Publications and Presentations

Journal Articles

Hanna, W., Wilson, J., and Timper, P. 2005. Registration of pearl millet parental line Tift 454. *Crop Science* 45:2670.

Hanna, W., Wilson, J., and Timper, P. 2005. Registration of pearl millet parental lines Tift 99D2A1/B1. *Crop Science* 45:2671.

Awala, S.K. and Wilson, J.P. 2005. Expression and segregation of stay-green in pearl millet. *International Sorghum and Millets Newsletter*. 46:87-100.

- Wilson, J.P., Jurjevic Z., Hanna, W.W., Wilson, D.M., Potter, T.L., and Coy, A.E. 2006. Host-specific variation in infection by toxigenic fungi and contamination by mycotoxins in pearl millet and corn. *Mycopathologia* 161:101-107.
- Timper, P. and Wilson, J.P. 2006. Root-knot nematode resistance in pearl millet from West and East Africa. *Plant Disease* 90:339-344
- Wu, X., Wang, D., Bean, S., and Wilson, J.P. 2006. Ethanol production from pearl millet by using *Saccharomyces cerevisiae*. *Cereal Chemistry* 83:127-131.

Breeding Grain Mold Resistance in High Digestibility Sorghum Varieties

**Project TAM 230
Dirk B. Hays
Texas A&M University**

Principal Investigator

Dr. Dirk B. Hays, Cereal Grain Development and Food Quality Genetics, Dept. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843, USA.

Cooperators

Dr. Ralph D. Waniska, Food Science and Technology, Texas A&M University, Dept. of Soil and Crop Sciences, College Station, TX 77843-2474

Dr. Monica Menz, Director, Laboratory of Plant Genome Technology (LPGT), Texas A&M University, Dept. of Soil and Crop Sciences, College Station, TX 77843-2474

Collaborating Scientists

Dr. Clint Magill, Dept. of Plant Pathology, Texas A&M University, College Station, TX 77845-8182

Dr. Gary C. Peterson, Texas Ag Experiment Station, Lubbock, TX 77843-2474

Dr. Louis K. Prom, USDA-REEE-ARS-SOA-SCR Lab CGR, College Station, TX 77845

Dr. Lloyd W. Rooney, Texas A&M University, Dept. of Soil and Crop Sciences, College Station, TX 77843-2474

Dr. William L. Rooney, Texas A&M University, Dept. of Soil and Crop Sciences, College Station, TX 77843-2474

This years work has been critical to the completion of graduate student programs and high impact technology transfer activities. The funding has provided stipends and supplies for the four students who have been recruited to work on this project. Sorghum lines have been bred that are adapted to Africa and Central America growing conditions, possess the high grain digestibility and high lysine content traits and have high levels of grain mold resistance. Our goal is to reach our objective of releasing these high yielding varieties for use by farmers thus significantly increasing yields of high quality, nutritionally superior grains and thus minimizing poverty and hunger in the region. The project is on track to achieve this by the end of the grant on June 30, 2007.

Development and Enhancement of Sorghum Germplasm with Sustained Tolerance to Biotic and Abiotic Stress

**Project PRF 207
Gebisa Ejeta
Purdue University**

Principal Investigator

Dr. Gebisa Ejeta, Dept. of Agronomy, Purdue University, West Lafayette, IN 47907

Collaborating Scientists

Dr. Aberra Deressa, Agronomist, EARO, Melkassa Research Station, Nazret, Ethiopia

Dr. Tesfaye Tesso, Sorghum Breeder, EARO, Melkassa Research Station, Nazret, Ethiopia.

Dr. Issoufou Kapran, Sorghum Breeder, INRAN, Niamey, Niger

Dr. Aboubacar Touré, Sorghum Breeder, IER, Bamako, Mali

Mr. C.K. Kamau, Sorghum Breeder, KARI, Kenya

Dr. Peter Esele, Plant Pathologist, NARO, Uganda

Dr. Hamis Sadaan, Sorghum Breeder, Department of Crops, Tanzania

Mr. Tesfamichael Abraha, Agronomist, DARE, Eritrea

Dr. Mitchell Tuinstra, Dept. of Agronomy, Kansas State University, Manhattan, KS 66506

Dr. Darrell Rosenow, Texas A&M Ag Research Center, Route 3, Lubbock, TX 79403

Dr. Kay Porter, Pioneer HiBred International, Plainview, TX 79072

Dr. Bruce Hamaker, Cereal Chemist, Dept. of Food Science, Purdue University, W. Lafayette, IN 47907

Dr. Peter Goldsbrough, Geneticist, Dept. of Horticulture, Purdue University, W. Lafayette, IN 47907

Dr. Layia Adeola, Animal Nutritionist, Dept. of Animal Sciences, Purdue University, W. Lafayette, IN 47907

One Ph.D. student is conducting his research in 2005-2006 on validating key molecular markers associated with tolerance of seedlings to cold temperatures'. A collaborative study underway on assessing the potential gene flow between sorghum species under natural conditions in native environments of sorghum in Africa will be finalized for journal publication during this extension year. New sorghum inbred lines with improved agronomic characteristics, but with the brown midrib trait that exhibits increased forage digestibility and biofuel conversion, will be extensively evaluated in hybrid combinations this coming year. The results of this year's research will be made available to the U.S. sorghum industry. Finally, a major breeding initiative to transfer drought tolerance associated with the stay green trait in sorghum will be advanced so that new sorghum inbred lines with enhanced drought tolerance will be available for distribution. These stay green lines have been developed in a seed parent background that combines excellent food grain characteristics with enhanced productivity and drought tolerance.

Enhancing the Utilization of Grain Sorghum and Pearl Millet through the Improvement of Grain Quality via Genetic and Nutrition Research

Projects

KSU 220A - Mitchell Tuinstra, Kansas State University

KSU 220 B- Joe Hancock, Kansas State University

TAM 220C - William Rooney, Texas A&M University

TAM 220D - Clint Magill, Texas A&M University

Principle Investigators

Dr. Mitch Tuinstra, Kansas State University, Dept. of Agronomy, Manhattan, KS 66506

Dr. Joe Hancock, Kansas State University, Dept. of Animal Sciences and Industry, Manhattan, KS 66506

Dr. William Rooney, Texas A&M University, Dept. of Soil & Crop Sciences, College Station, TX 77843

Dr. Clint Magill, Texas A&M University, Dept. of Plant Pathology & Molecular Biology, College Station, TX 77843

Collaborating Scientists

Dr. Issoufou Kapran, Plant Breeding, INRAN Rainfed Crops Program, INRAN, BP 429, Niamey, Niger

Dr. Salissou Issa, Head of Animal Husbandry, INRAN Rainfed Crops Program, INRAN, BP 429, Niamey, Niger

Dr. Aboubacar Touré, Sorghum Breeding, IER/Sotuba Research Station, BP 262, Bamako Mali

Dr. Carlos Campabadahl, Professor Emeritus of Animal Nutrition and LANCE Director, Centro de Investigaciones en ... Nutricion Animal, Universidad de Costa Rica, San Jose, Costa Rica

Dr. Scott Bean, USDA-ARS Grain Marketing and Production Research Center, Manhattan, KS 66506

Dr. Mamourou Diourté, Pathology, IER/CRRAd Sotuba, Bamako, Mali

Dr. Paul Marley, Pathology, Institute for Agricultural Research, Samaru, Zaria, Nigeria

Mr. Adama Neyya, Pathology, INERA, Faroko-BA Station, Bobo Dioulasso, Burkina Faso

KSU 220A

The objectives of KSU-220 are to enhance the utilization of grain sorghum and pearl millet through the improvement of grain yield and quality via genetic and nutrition research. Plant breeding efforts focus on selection of new varieties having improved nutritional value. These efforts are aided by development of techniques to rapidly quantify food and feed quality characteristics. Large-seeded, early-maturing, sorghum varieties currently are being evaluated for adaptation to conditions in West Africa.

Since *Striga* is the single most devastating pest of sorghum in West Africa, crop improvement efforts are focused on developed locally-adapted, *Striga*-resistant, sorghum hybrids and varieties with improved grain quality and nutritional value. An array of previously uncharacterized sources of *Striga* resistance has been identified in guinea sorghum cultivars by collaborators in Mali and Niger. These varieties are being evaluated for performance in *Striga* infested fields in Mali and Niger to determine the stability of expression and mode of inheritance of *Striga* resistance. A novel herbicide seed treatment technique also has been developed for controlling *Striga* infestation of sorghum. This technique has been shown to be highly effective in greenhouse and field trials. Field testing of this new technology will be continued in the 2006. These traits are being incorporated into elite sorghum varieties.

Technical assistance promoting the use of improved sorghum and millet grains in poultry feeding is being provided in the developing regions of West Africa and Central America. These technology transfer efforts will promote the development of new entrepreneurial opportunities for production of eggs, meat, and other animal products.

KSU 220B

This project has been working on completion and dissemination of a brochure (in English, Spanish, and French) that will highlight the primary components of the outreach/technology transfer efforts and will improve marketability of sorghum and millet in these regions of the world. In addition, there are two students (one from Central America and one from West Africa) funded partially or completely from this project (KSU 220B). The project has been working on completion of graduate student training. In conclusion, KSU 220B feels that recognition of the true nutritional value of grain sorghum and millet by animal producers will lead to greater health and productivity of both animals and humans in regions of the world where hunger and poverty are major issues. Their research has been focused on development of value-enhanced sor-

ghum and millet grains and the transfer of animal feeding technologies to promote development of new entrepreneurial opportunities for production of meat and other animal products in Africa and Central America. Enhanced value of these crops will contribute to a shift of sorghum and pearl millet from subsistence to cash crops in developing countries and make sorghum more competitive with other cereal grains for end-use applications in the U.S. and our host countries. Finally, development of more competitive sorghum and millet cultivars will allow producers to conserve water resources that would otherwise be used by less water-efficient crops.

TAM 220C

During this year this project has focused on completing the objectives of the program with particular emphasis on activities related to grain quality. In conjunction with TAM-230, the development of populations necessary for the evaluation of protein digestibility and grain weathering will be completed. In addition, a final year of a study evaluating the genotype x environment interaction of protein digestibility and grain weathering will be completed. Grain from that study will be used to determine the efficacy of those genotypes in processing and potential for alternative uses. Evaluation of dual-purpose forage (bmr and sweet) sorghum cultivars and hybrids for suitability in the U.S. will be completed and they will be evaluated in Central America in 2006-2007. Thus this extension will allow the identification of those lines with best potential for release in Central America. A portion of the funds are allocated to support a graduate student who will complete his research. Finally, germplasm developed through the support of INTSORMIL will be prepared for release and distribution in the final year of this program. Funds in this budget are designated to complete this process.

Brown, PJ, PE Klein E. Bortiri, C. Acharya, WL Rooney and SK Kresovich. Inheritance of Inflorescence Architecture in Sorghum. *Theor. Appl. Genetics* 113: 931-942.

Rodriguez-Herrera R., R.D. Waniska, W.L. Rooney, C.N. Aguilar and J.C. Contreras-Esquivel. 2006. Antifungal Proteins during Sorghum Grain Development and Grain Mold Resistance. *J. of Phytopathology* 154: 565-571.

Kuhlman, L.C., D.R. Pring, W.L. Rooney, H.V. Tang. 2006. Allelic Frequency at the Rf3 and Rf4 Loci and the Genetics of A3 Cytoplasmic Fertility Restoration in Converted Sorghum Lines. *Crop Sci.* 46:1576-1580.

Rodríguez-Herrera*, R., R. A. Frederiksen, W. L. Rooney, I. Kollo, C. N. Aguilar-González and A. Quero-Carrillo. 2006. Grain Molding Fungi Association in Food Type Sorghum Kernels and Their Effects on Germination. *Plant Pathology Journal.* 5: 221-227.

TAM 220D

This project has been working on completion of a study involving the use of biotechnology procedures to quantify disease defense response genes in sorghum florets. Seriba Katilé, a Ph.D. student from Mali working on this project has accumulated data for one or more genes in 3 different defense pathways in a set of

10 cultivars that show varying degrees of resistance to grain mold. The same cultivars have been inoculated with *Curvularia lunata* and *Fusarium thapsinum*, the 2 most common grain mold fungi, and RNA extractions have been made from the samples collected in liquid nitrogen. Primer sets for 12 genes, including two constitutively expressed genes for use as controls, have been developed for use in quantitative analysis of gene expression (mRNA levels). It is anticipated that data collection and analysis will be completed by June 30, 2007.

The project also recently succeeded in tagging a dominant gene that confers anthracnose resistance to sorghum cultivar SC748 with easily scored, PCR-based markers. The markers also allowed the chromosomal map location of the gene to be determined. (A manuscript is under final review by the authors for submission to *Theoretical and Applied Genetics*.) Data collected in 2005-2006 from progeny tests for another cross (BTx623, susceptible, by SC155-14E, resistant) confirmed the identity of 37 fully susceptible F3 progeny rows and 30 rows where all plants in the segregating material are resistant. Before the closing date of this project in 2007, DNA from 12 of each class of homozygous F2.-3 lines will be used to detect closely-linked AFLP and/or SSR markers that will also serve to identify the most likely map location of this second gene. The use of the gene tags will make combining the two sources of resistance much simpler through the use of marker assisted selection. Lines containing both genes are predicted to provide long-term yield stability by decreasing the risk of resistance break-down.

Training provided to Drs. Stephen Nutsugah (Ghana) and Mamourou Diourté (Mali) as well as Mr. Katilé, will allow them to take advantage of PCR-based DNA methods for marker-assisted selection and diagnostics. In the case of Mali, the tools needed for doing so have also been provided for direct use at the IER station. The ability to use easily scored DNA markers to identify and combine genes that contribute resistance to anthracnose or grain mold resistance should be of great value, since both diseases are severe constraints to stable sorghum production in the West Africa region.

Germplasm Enhancement for Resistance to Insects and Improved Efficiency for Sustainable Agriculture Systems

Project TAM 223
Gary C. Peterson
Texas A&M University

Principal Investigator

Gary C. Peterson, Professor, Sorghum Breeding & Genetics, Texas Agricultural Experiment Station, Lubbock, TX 79403

Collaborating Scientists

Dr. Medson Chisi, Sorghum Breeding, Golden Valley Research Station, Box 54, Fringila, Zambia

Dr. Neal McLaren, Plant Pathology, Dep. of Plant Sciences, University of the Free State, Bloemfontein, Orange Free State, South Africa

Dr. Hannalene du Plessis, Entomology, ARC - Grain Crops Institute, Private Bag X1251, Potchefstroom 2520, Republic of South Africa

Ing. Rafael Obando, Sorghum Breeding, Instituto Nicaragense de Tecnologia, Edificio Mar, Apdo.1247, Managua, Nicaragua

Ing. Rene Clara, Sorghum Breeding, CENTA, Apartado Postal 885, San Salvador, El Salvador

Dr. David Munthali, Entomology, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana

Mr. Niaba Teme, Sorghum Breeding, IER Sotuba, B.P. 438, Bamako, Mali, (currently Graduate Research Assistant, Texas A&M University Agricultural Research and Extension Center, Rt. 3, Box 219, Lubbock, TX 79403-9803)

Ms. Phoebe Ditshipi, Plant Pathology, Dep. of Agricultural Research, Private Bag 0033, Gaborone, Botswana (currently Ph.D. student in plant pathology, University of Free State, Bloemfontein, Free State, South Africa)

Mr. Godwin Kaula, Plant Pathology, Ministry of Agriculture and Cooperatives, Mt. Makulu Research Station, Private Bag 7, Chitanga, Zambia

Dr. Bonnie B. Pendleton, Entomology, Division of Agriculture, West Texas A&M University, Canyon, TX 79016

Dr. W.L. Rooney, Sorghum Breeding, Dep. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843

Dr. Lloyd Rooney, Cereal Chemistry, Dep. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843

Objectives

- Obtain and evaluate germplasm for resistance to arthropod pests and other stresses including drought and selected diseases.
- Develop and release high-yielding, agronomically improved sorghums resistant to selected insects and other biotic or abiotic stresses.
- Develop and release high grain yield sorghums with multiple stress resistance and improved grain quality traits.
- Utilize molecular biology to increase understanding of plant traits for stress resistance.

the progress and status of an INTSORMIL supported graduate student (Ms. Phoebe Ditshipi). Ms. Ditshipi is conducting research on stalk rots of sorghum. Met with Mr. Leo Mpofo to discuss Ph.D. research on grain mold resistance in grain sorghum. At Potchefstroom, evaluated the sugarcane aphid test and planned future activity. Discussed the possibility of testing selected entries in on-farm trials for potential use as varieties. In Zambia, discussed the status of collaborative activity in the country and region. Participated in regional sorghum training workshop. Traveled to Livingstone region to evaluate CARE program on production of tan plant, white grain sorghum by small scale farmers for off-farm sale.

Networking Activities

Workshops and Meetings

Participated in Southern Africa regional sorghum breeders workshop, 24-29 April, 2006 in Zambia.

Research Investigator Exchanges

South Africa and Zambia - 17 April - 5 May 2006. During a visit to the University of the Free State at Bloemfontain reviewed

Germplasm and Research Information Exchange

Germplasm was distributed to private companies as requested and to the following countries, including but not limited to: Nicaragua, El Salvador, Guatemala, South Africa, Botswana, Zambia and Mozambique. Entries in the All Disease and Insect Nursery (ADIN) were evaluated at many locations domestically and internationally.

Germplasm previously developed and released by this project is used by commercial seed companies in hybrid production.

Served on Ph.D. committee of N. Teme (Mali) at Texas Tech University. Served on the M.S. committee of L. Mpofu (Zimbabwe) and J. Mutiliano (Mozambique) at Texas A&M University.

Other Cooperators

Collaboration with the following scientists was important in the activities of TAM-223:

Dr. R. D. Waniska, Cereal Chemistry, Dep. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843

Dr. G.N. Odvody, Plant Pathology, Texas Agricultural Experiment Station, Texas A&M University Agricultural Research and Extension Center, Route 2 Box 589, Corpus Christi, TX 78406-9704

Crop Utilization and Marketing



An Evaluation of New Market Development and Marketing Strategies on Sorghum and Millet Farmers' Income in Tanzania and Zambia

Project OSU 200
Donald Larson and J. Mark Erbaugh
Ohio State University

Principal Investigator

Donald Larson, Ohio State University, CMPS/3064 Smith Lab/174 Eighteenth Ave, Columbus, OH 43210
J. Mark Erbaugh, Ohio State University, IPIA/113 Ag Admin Building/2120 Fyffe Road, Columbus, OH 43210

Collaborating Scientists

Emmanuel Mbiha, Sokoine University of Agriculture, Morogoro, Tanzania
Fredy Kilima, Sokoine University of Agriculture, Morogoro, Tanzania
Gelson Tembo, University of Zambia, Lusaka, Zambia
Priscilla Hamukwala, University of Zambia, Lusaka, Zambia

The program completed research field work for one M.S. candidate (Zambia) and one Ph.D. candidate (Tanzania). Research involves the evaluation of the effects of new market development and marketing strategies for sorghum and millet on farmers' income in Tanzania and Zambia. The INTSORMIL/CRSP issued a request for proposals to strengthen the marketing research component for eastern and southern Africa. The OSU research work was initiated as part of this effort nearly one year ago. We worked to complete the analyses of the farm level data that was collected and complete an in-depth study of the entire value added supply chain for one of three potential valued added markets for sorghum and millet. The three markets with the most potential are fortified food processing, animal feeds, and commercial beer brewing. A diagnostic report examining the problems and constraints of the selected supply chain will be prepared by the end of this year. The report will contain recommendations on how the value added supply chain can be improved. Achieving a successful supply chain model has strong possibilities for expanding and replicating this model to other value added markets for sorghum and millet. The research data will be used for host-country graduate student thesis preparation.

Major achievements

Ohio State University is conducting marketing research with faculty at the Department of Agricultural Economics and Agribusiness, Sokoine University of Agriculture (SUA), Faculty of Agriculture, Morogoro, Tanzania and the Department of Agricultural Economics and Extension Education, the University of Zambia (UZ), School of Agricultural Sciences, Lusaka, Zambia. In each country, a questionnaire was developed with host country collaborators to survey farmers who use new and traditional production technologies and marketing strategies. Usable questionnaires were completed with slightly over 100 farmers in major sorghum and millet producing areas in each country (Dodoma in Tanzania and Siavonga in Zambia). Many additional interviews with key informants in the private and public sectors of the host countries were

completed to obtain valuable insights about the adoption and profitability of new sorghum production and marketing technology. The key informants included farmers, input supply firms, sorghum buyers, processors, and wholesalers in the sorghum beer brewing and food processing value chain for the 'new technology' users and the 'traditional technology' users. Public sector interviews included USAID/Tanzania, USAID/Zambia, sorghum and millet researchers (e.g., INTSORMIL), government policy makers, statistical agencies, CARE, and others such as the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

An interim report of the findings has been completed and a final report is due for completion by September 30, 2006. A paper entitled "Strategic Management Options for Growing Power Foods Ltd.: Dar Es Salaam, Tanzania" by E. R. Mbiha, Donald W. Larson, J. Mark Erbaugh, and Thomas Worley was presented at the International Food and Agribusiness Management Association (IAMA) 16th Annual World Forum and Symposium in Buenos Aires, Argentina. June 9-14, 2006.

Chemical and Physical Aspects of Food and Nutritional Quality of Sorghum and Millet

**Project PRF 212
Bruce R. Hamaker
Purdue University**

Principal Investigator

Bruce R. Hamaker, Dept. of Food Science, Purdue University, West Lafayette, IN 47907

Collaborating Scientists

Mr. Kaka Saley, Cereal Scientist; Mr. Moustapha Moussa, Cereal Technologist; Ms. Ramatou Seydou, Chemist; Dr. Issoufou Kapran, Sorghum Breeder; INRAN B.P. 429, Niamey, Niger

Ms. Senayit Yetneberk, Cereal Scientist, EARO, Nazret Research Station, P.O. Box 436, Nazret, Ethiopia

Ms. Betty Bugusu, Cereal Scientist, KARI, Katumani Natl Dryland Farming Res. Ctr, P.O. Box 340, Machakos, Kenya

Mr. Ababacar N'Doye, Research & Development Director, ITA, B.P. 2765, Dakar, Senegal

Dr. Iro Nkama, Professor, University of Maiduguri, P.O. Box 1069, Maiduguri, Nigeria

Mr. Boniface Bougouma, Cereal Scientist, IRSAT/DTA, B.P. 7047, Ouagadougou, Burkina Faso

Dr. John Taylor, Cereal Chemist, University of Pretoria, Food Technology Department, Pretoria 0002, South Africa

Dr. Adam Aboubacar, Assistant Professor, University of Wisconsin-Stout, P.O. Box 790, Menomonie, WI 54751

Dr. Arun Chandrashekar, Cereal Chemist, CFTRI, Dept. of Food Microbiology, Mysore 570013, India

Dr. Gebisa Ejeta, Sorghum Breeder; Dr. Layi Adeola, Poultry Nutritionist; Dr. Moustapha Benmoussa, Plant Molecular Biologist, Purdue University, West Lafayette, IN 47907

Dr. Brian Larkins, Plant Molecular Biologist, University of Arizona, Tucson, AZ 85701

Dr. Tae Wae Moon, Food Chemist, Seoul National University, Seoul, Korea

This project is completing studies having high impact potential including the completion of a Nigerien graduate student's M.S. degree, to complete partially-supported research on sorghum protein utilization, and to write and submit articles for publication. More specifically these activities will include:

- Completion of the student project of Moustapha Moussa on the development of low-cost commercially profitable pre-gelatinized sorghum and millet flours for thin and thick porridges. These products hold exceptional promise as convenience foods for urban consumers in West Africa who prefer to consume thin porridges for breakfast, light mid-day meals, and snacks and would benefit from instant porridges to be mixed with hot water. Still to be completed during the extension year are optimization of the process, shelf life studies, completion of sensory evaluation, as well as promotion with donors in Niger.
- Completion of a study, in collaboration with A. N'Doye of the Institut de Technologie Alimentaire, Dakar, Senegal on the feasibility of using sorghum and millet storage proteins as viscoelastic polymers to make leavened products.
- Write and submit publications on pre-gelatinized sorghum and millet flours and sensory evaluation studies conducted in Niger, on new uses for sorghum and millet proteins and on high digestibility sorghums.

Food and Nutritional Quality of Sorghum and Millet

Project TAM 226
L.W. Rooney
Texas A&M University

Principal Investigator

Lloyd W. Rooney, Professor, Food Science & Agronomy, Cereal Quality Lab, Soil & Crop Sciences Dept., Texas A&M University, College Station, Texas 77843

Cooperator: Ralph D. Waniska, Professor, Food Science, Cereal Quality Lab, Texas A&M University, College Station, Texas 77843

Collaborating Scientists

Dr. A. Touré, Sorghum Breeder, Institute Economic Rurale, Bamako, Mali

Dr. G. Peterson, Texas A&M Ag Research and Extension Center, Lubbock, TX 79401

Drs. W.L. Rooney and D. Hays, Texas A&M University, Soil & Crop Sciences, College Station, TXs 77843-2474

Drs. Mitch Tuinstra, Dept. of Agronomy, and Joe Hancock, Dept. of Animal Sciences and Industry, Kansas State University, Manhattan, KS 66506-5506

Dr. Sergio Serna-Saldivar, Professor and Head, Food Science, ITESM de Monterrey, Monterrey, Mexico

Professor John R.N. Taylor, Head, Food Technology Dept., University of Pretoria, Pretoria 0002, South Africa

Ms. Ruth Vilma Calderon, Food Technologist, and Ing. René Clará, Sorghum Breeder, CENTA, Km 331/2 Carretera a Santa Ana, San Andrés, La Libertad, El Salvador

Ms. Eliette Palacio, Seed Technologist, INTA, Managua, Nicaragua

Dr. Javier Bueso, Associate Professor, Escuela Agrícola Panamericano, Zamorano, Honduras

Dr. John Sanders, Professor, Agriculture Economics, Purdue University, W. Lafayette, IN 47907-2056

Summary

New, more-efficient, higher-yielding white tan photosensitive varieties from the IER breeding program in Mali have excellent properties for food processing. They escape significant weathering/molding that adversely affects earlier insensitive white tan sorghums which led to their failure. Farmers were pleased with the grain quality for their own food and appreciated the opportunity to sell the grain at a potential premium. The principle of supply chain management from seed to food products has been demonstrated; however, more work to obtain wide-spread participation is required.

Similar situations exist in El Salvador where small farmers have vertically integrated and sell their own white tan sorghums in the form of baked products. There are some significant successes in this area.

United States value-enhanced white food sorghums developed in part by this project and promoted by the US Grains Council in Japan continued to be used by the Japanese food industry to market snacks and several other products. The white sorghums are color sorted, decorticated, and used as an ingredient in a wide variety of foods including brewing. The cost of value-added white sorghums is competitive with domestic Japanese rice.

Several small mills in the US are producing sorghum flour for niche markets. The operations are small, but produce sorghum flour and other products that have been made into foods for Ce-

liac-Sprue patients and ethnic groups. Other food companies are developing new food products and preparing mixes for special markets.

Special sorghums with high levels of phenols and antioxidants were extruded to produce snacks with high levels of antioxidants. The extruder is a low-cost, short-barrel friction type that could be used by small companies in targeted countries, i.e., Central America. The extrudates are high in dietary fiber as well as antioxidants. We found that whole, cracked and decorticated sorghums produced a wide variety of extrudates. The extruded whole grain products have significant appeal as health foods. Bread machine mixes with sorghum bran, gluten, flax and barley flour produced good-quality bread with a natural dark color and improved nutritional value.

We continue to monitor the quality of new food-type sorghums in special sorghum nurseries grown in the sorghum belt by collaboration with Dr. Tuinstra, Rooney, Peterson and others. The IFSAT trials consisting of advanced food sorghums of potential value in host countries is evaluated for quality annually in several locations. Several parental sorghum lines released from our program are used in commercial food hybrids. New commercial sorghum hybrids with tan plant white pericarp color were released by commercial hybrid seed companies. Red tan plant hybrid sorghums have excellent milling properties compared to red purple plant sorghums.

Tannin and other special sorghums have excellent levels of antioxidant power, high dietary fiber and impart attractive dark natural color to baked products. They can be incorporated into a wide variety of products. Small quantities of tannin sorghum bran were an effective preservative for ground beef patties.

Workshops on food sorghums and special tannin sorghums as health foods were presented in South Africa, Central America, Mali and to technical conferences and industry personnel in the USA.

Three students completed MS degrees in Food Science and Technology. Three short-term trainees from Central America and Africa were hosted.

Publications and Presentations

Journal Articles

- Awika, J.M., C.M. McDonough, and L.W. Rooney. 2005. Decorating sorghum to concentrate healthy phytochemicals. *J Ag and Food Chem* 53:6230-6234.
- Dykes, L., L.W. Rooney, R.D. Waniska, and W.L. Rooney. 2005. Phenolic compounds and antioxidant activity of sorghum grains of varying genotypes. *J Ag & Fd Chem* 53:6813-6818.
- Rooney, L.W. 2005. Ten myths about tannins in sorghums. *International Sorghum and Millets Newsletter* 46:3-5. SICNA/ICRISAT.

Dissertations and Theses

- de Castro, A. May 2006. In vitro starch digestibility and estimated glycemic index of sorghum products. MS Thesis. Texas A&M University, College Station, TX. 113 pp.
- Perez Gonzalez, A.J. December 2005. Specialty sorghums in direct-expansion extrusion. MS Thesis. Texas A&M University, College Station, TX. 115 pp.
- Cedillo Sebastian, G. December 2005. Nutraceutical tortillas and tortilla chips prepared with bran from specialty sorghums. MS Thesis. Texas A&M University, College Station, TX. 109 pp.

Miscellaneous Publications

- Rooney, L.W. 2005. Food and nutritional quality of sorghum and millet, Project TAM-226. INTSORMIL Annual Report 2005, University of Nebraska, 103-111.

Abstracts

- Dlamini, N., C.M. McDonough, L. Dykes, L.W. Rooney, and J. Taylor. 2006. Ready-to-eat products prepared by the extrusion cooking of whole and decorticated sorghums that are high in antioxidants. Institute of Food Technology Annual Meeting and Food Expo, June 24-28, Orlando, FL (Poster). <http://www.abstractsonline.com/viewer/>
- De Castro, A., C.M. McDonough, Waniska, R.D., and L.W. Rooney. 2006. Effect of extrusion on starch availability of sorghum products. Institute of Food Technology Annual Meeting

- and Food Expo, June 24-28, Orlando, FL (Poster). <http://www.abstractsonline.com/viewer/>
- Shin, D., R. Miller, J. Keeton, L.W. Rooney, and R.D. Waniska. 2006. Antioxidant, color and sensory properties of sorghum bran in pre-cooked ground beef patties varying in fat. Institute of Food Technology Annual Meeting and Food Expo, June 24-28, Orlando, FL (Poster). <http://www.abstractsonline.com/viewer/>
- Turner, N.D., A. Diaz, S.S. Taddeo, J. Vanamala, C.M. McDonough, L. Dykes, M.E. Murphy, R.J. Carroll, and L.W. Rooney. 2006. Bran from black or brown sorghum suppresses colon carcinogenesis. *Experimental Biology: Advancing the Biomedical Frontier*, San Francisco, CA. #394.6. <http://www.eb2006-online.com/pdfs/006564.PDF?PHPSESSID=3384411635c50bc0ea6bdd8f67ecf>
- Calderon, V.R, F. Herrera, R. Clara, and L.W. Rooney. 2005. Sorghum utilization for human consumption in El Salvador, C.A. American Association of Cereal Chemists (AACC) International Conference, September 11-14, Orlando, FL. <http://www.aaccnet.org/meetings/2005/abstracts/p-277.htm>
- Cedillo, G., A. de Castro Palomino, C.M. McDonough, R.D. Waniska, and L.W. Rooney. 2005. Corn tortillas high in antioxidants and dietary fiber. American Association of Cereal Chemists (AACC) International Conference, September 11-14, Orlando, FL. <http://www.aaccnet.org/meetings/2005/abstracts/p-308.htm>
- de Castro Palomino, A., C.M. McDonough, R.D. Waniska, and L.W. Rooney. 2005. In-vitro starch hydrolysis index and estimated glycemic index of sorghum products. American Association of Cereal Chemists (AACC) International Conference, September 11-14, Orlando, FL. <http://www.aaccnet.org/meetings/2005/abstracts/p-275.htm>
- Dlamini, N.R., J.R.N. Taylor, C.M. McDonough, and L.W. Rooney. 2005. Antioxidant properties of whole grain African sorghum-based foods. American Association of Cereal Chemists (AACC) International Conference, September 11-14, Orlando, FL. <http://www.aaccnet.org/meetings/2005/abstracts/p-272.htm>
- Perez, A.J, A. de Castro, D. Guajardo, and G. Cedillo. 2005. Krunchips multi colored all natural tortilla chips. American Association of Cereal Chemists (AACC) International Conference, September 11-14, Orlando, FL.
- Perez-Gonzalez, A.J., C.M. McDonough, M.N. Riaz, and L.W. Rooney. 2005. Extrusion of whole-grain and milled specialty sorghum. American Association of Cereal Chemists (AACC) International Conference, September 11-14, Orlando, FL. <http://www.aaccnet.org/meetings/2005/abstracts/p-187.htm>
- Hines, L.R. and L.W. Rooney. 2005. Development of an improved gluten-free bread with dietary fiber, antioxidants, and omega-3 fatty acids. Institute of Food Technology Annual Meeting and Food Expo, July 17-20, New Orleans, LA. (Poster)
- Cedillo, G., C.M. McDonough, R.D. Waniska, and L.W. Rooney. 2005. Nutraceutical corn tortillas prepared using bran from specialty sorghums. Institute of Food Technology Annual Meeting and Food Expo, July 17-20, New Orleans, LA. (Poster)
- Perez-Gonzalez, A. 2005. Performance of specialty sorghums in whole-grain extrusion. Institute of Food Technology Annual

Meeting and Food Expo, July 17-20, New Orleans, LA. (Presentation)

Proceedings/Presentations

Gu, L., S.E. House, L.W. Rooney, and R.L. Prior. 2006. Sorghum bran in the diet dose dependently increased excretion of catechins and microbial derived phenolic acids in rats. *Experimental Biology: Advancing the Biomedical Frontier*, April 1-5, San Francisco, CA.

Rooney, L.W. 2006. Rice & Sorghum Extrusion Properties. *Snack Foods Processing Short Course*, March 12-17, College Station, TX.

Rooney, L.W. 2006. Progress in sorghum utilizations for food and feed, 5th Australian Sorghum Conference January 30 - February 2, 2006, Gold Coast, Australia.

Rooney, L.W. 2005. Discussion: Developing supply chain managements. *Technology Diffusion and Supporting Services for Food Processors in the Sahel*, December 14-15, Saly, Senegal.

Rooney, L.W. 2005. The process and pitfalls of developing supply chains. *Technology Diffusion and Supporting Services for Food Processors in the Sahel*, December 14-15, Saly, Senegal.

Rooney, L.W. 2005. Sorghum utilization and health benefits. *Frito-Lay R&D personnel*. September 23, Plano, TX.

Entrepreneurship and Product Development in East Africa: A Strategy to Promote Increased Use of Sorghum and Millet.

Project UNL 220

David S. Jackson

University of Nebraska – Lincoln

Principle Investigator

Dr. David S. Jackson, University of Nebraska - Lincoln, Dept. of Food Science & Technology, 256 Food Industry Bldg, . Lincoln, NE 68583

Collaborating Scientists

Ms. Jill Gifford, University of Nebraska, Food Processing Center, Lincoln, NE 68583

Dr. Joseph J. Mpagalile, Sokoine University of Agriculture, Dept. of Food Science and Technology, P. O. Box 3006, Morogoro, Tanzania

Ms. Joan Scheel, University of Nebraska, Food Processing Center, Lincoln, NE 68583

Dr. Curt Weller, University of Nebraska, Dept. of Biological Systems Engineering, Lincoln, NE 68583

High impact activities are being conducted during this period. This project is actively working with 30-40 entrepreneurial business clients in Tanzania. The entrepreneurs are either already engaged in processing small quantities of sorghum products or are conducting sorghum food product development / business development activities that will lead to the marketing of new products. The project provides integrated marketing and product/process development services to these clients with the aim of 1) establishing a product development / market development assistance infrastructure at Sokoine University of Agriculture, 2) developing entrepreneurial food business and micro-enterprises that increase food and economic security, and 3) “pulling” sorghum and millet through the marketing channel, thus providing consumers with improved food choices and providing farmer/producers with increased market stability/incomes.

During this period we are completing the following activities:

- Provide training of business clients with the “From Recipe to Reality and From Product to Profit” workshop series.
- Provide customized (one-to-one) technical and business development support.
- Localize development of program materials for other East African nations. Evaluate the “pull model” of increasing sorghum/millet consumption) and document specific financial and social impacts (specific businesses developed and/or supported, increase(s) in products sold, and increase(s) in business income.

Host Country Program Enhancement



Central America (El Salvador, Honduras, Nicaragua)

Stephen C. Mason
University of Nebraska

Coordinators

Ing. René Clará Valencia, Plant Breeder, CENTA, Apdo. Postal 885, San Salvador, El Salvador (Central America Regional Host Coordinator)

Ing. Rafael Obando Solis, Agronomist, CNIA/INTA, Apdo. 1247, Managua, Nicaragua (Nicaragua Country Coordinator)

Ing. Mario Enesto Parada Jaco, Entomologist, CENTA, Apdo. Postal 885, San Salvador, El Salvador (El Salvador Country Coordinator)

Ing. Hector Sierra, Agronomist, DICTA, Choluteca, Honduras (Honduras Country Coordinator)

Dr. Stephen C. Mason, 229 Keim Hall, Dept. of Agronomy, University of Nebraska, Lincoln, NE 68583-0915 (Central America Regional Coordinator)

Collaborating Scientists

Mr. Francisco Vargas, Agronomist, ANPROSOR, Nicaraguan Grain Sorghum Producers Association, Managua, Nicaragua

Mr. Sergio Pichardo Guido, Plant Pathologist, UNA, Managua, Nicaragua

Ms. Yanet Gutiérrez Gaitán, Plant Pathologist, UNA, Managua, Nicaragua

Ms. Martha Zamora, Entomologist, UNA, Managua, Nicaragua

Ing. Reina Flor Guzmán de Serrano, Plant Pathologist, CENTA, San Andrés, El Salvador

Ing. Carlos Armando Borja Melara, Plant Pathologist, CENTA, San Andrés, El Salvador

Ing. Jaime Ayala, Entomologist, CENTA, San Andrés, El Salvador

Mr. Leopoldo Serrano Cervantes, Entomologist, Universidad de El Salvador, San Salvador, El Salvador

Ing. Carmen Gutiérrez D., Entomologist, INTA, Managua, Nicaragua

Ing. Humberto Salvador Zeledón, Plant Breeder, CENTA, San Andrés, El Salvador

Ing. Maximo Hernández Valle, Agronomist, CENTA, San Andrés, El Salvador

Ing. Quirino Argueta Portillo, Agronomist, CENTA, San Andrés, El Salvador

Ing. Orlando Téllez Obregón, Soil & Water Scientist, Posoltega, INTA, Nicaragua

Mr. Leonardo García Centeno, Agronomist, UNA, Managua, Nicaragua

Ms. Vilma Ruth Calderón, Food Scientist, CENTA, San Andrés, El Salvador, El Salvador

Mr. Guillermo Bonilla, Food Scientist, UJMD, San Salvador, El Salvador

Dr. Henry Pitre, Dept. of Entomology and Plant Pathology, Mississippi State University, Mississippi State, MS 39762

Dr. Lloyd Rooney, Dept. of Soil & Crop Sciences, Texas A & M University, College Station, TX 77843

Dr. Gary Peterson, Texas A & M University Ag Research and Extension Center, Rt. 3 Box 219, Lubbock, TX 79401-9803

Dr. Larry Claflin, Dept. of Plant Pathology, Kansas State University, Manhattan, KS 66506-5502

Dr. W.L. Rooney, Dept. of Soil and Crop Sciences, Texas A & M University, College Station, TX 77843

Dr. Darrell T. Rosenow, Texas A & M Univ. Ag Research & Extension Center, Rt. 3 Box 219, Lubbock, TX 79401-9803

Dr. John Sanders, Dept. of Ag Economics, Purdue University, West Lafayette, IN 47097-1145

Dr. Sergio O. Serna-Saldivar, Instituto Tecnológico y de Estudios Superiores, Monterrey, Mexico

Activities and Anticipated Products

Initiated publication of extension bulletins and production guides on sorghum management recommendations, including agronomy, economics, breeding methods, plant protection and grain utilization.

Output: Improved technology transfer by extension services and NGOs.

Evaluated potential for use of microdose fertilizer application for photoperiod sensitive varieties grown on poor soil fertility situations on hillsides in Central America.

Output: Determined if this new technology from West Africa has potential to improve grain sorghum production in Central America.

Continued research to identify high nitrogen use efficient sorghum varieties that respond well to low applications rates of nitrogen fertilizer.

Output: Select varieties that produce high yields with relatively low fertilizer input rates.

Promoted use of nitrogen fertilizer and the use of intercropped mungbean for nitrogen supply through field demonstration, publication of extension bulletins, and by developing closer working relationships with fertilizer dealers and NGOs.

Output: Improved extension of nitrogen fertilizer management recommendations to producers while building relationships with input suppliers and technology transfer agents, facilitated a process that makes fertilizer available at a more economical cost, thus promoting fertilizer use and increased yields.

Helped with transfer of the improved green chop variety CENTA SS-44 through field demonstrations.

Output: Research suggests that adoption of the variety with good management can increase milk production by 25%.

Continued breeding program to improve yield, grain quality and pest resistance of photoperiod sensitive and insensitive varieties for grain and forage uses.

Output: Development of superior varieties and hybrids for release and diffusion in Central America that increase yield, biotic and abiotic stress tolerance, and grain (and/or forage) quality.

Held meetings with producers to improve fertilizer and pest management, and bakers to increase utilization of sorghum flour.

Output: Producers will increase yields and bakers will increase profitability by increasing use of sorghum flour.

Transferred the improved variety's RCV, Sureño, 85SCP805 and ES-790 by producing one metric ton of seed of each in both El Salvador and Honduras, teaching small farmers to produce their own seed, and distribution of seed to small farmers.

Output: Increased adoption of improved varieties and farmer yields, and establishment of sustainable production by promoting artisanal seed production by small-scale farmers.

Continued graduate degree training of three students (entomology, pathology and food science) and provide short-term training to one economist in impact assessment.

Output: Increased scientific capability of national programs in Central America.

Major achievements of the past year are transfer of the improved high N use efficient sorghum variety 85SCP805 (with and without fertilizer application) to 141 small farmers, and transfer of the improved variety's ES-790, CENTA S-3, 86EO226 and CENTA RCV to approximately 500 small farmers. The improved photoperiod sensitive variety 85-SCP-805 with high yield potential and nitrogen use efficiency was validated on 40 farms. The new variety with 47 kg ha⁻¹ N fertilizer application increased grain yield by 800 kg ha⁻¹ (about 25%) over the local variety without N fertilizer. In addition, rapid progress is being made in validation and seed increase of the forage hybrid ICSA275 X TX2784, with formal release planned for November 2005. The variety/hybrid pipeline at CENTA and CNIA/INTA indicates the potential

for release of several improved grain sorghum varieties/hybrids in 2006. Progress was made in developing improved integrated crop and pest management programs. Improved ties with the food processing industries in El Salvador and Nicaragua were achieved through workshops and personal contacts, and one company, GUMARSAL has participated in grain quality research and plans to mill sorghum flour. Graduate and undergraduate educational, and short-term training efforts have improved the human capital available for sorghum research and technology transfer in Central America. In addition research and technology transfer efforts for poultry nutrition in Central America have focused on seminars given in Nicaragua and at the RAPCO short courses in Costa Rica. Dr. Hancock/KSU used the RAPCO short courses to promote sorghum as a component in animal feeds (especially for poultry). Attendees for the short courses (limited to 35 each year) were representatives from the major livestock/feed producers in most of Latin America (i.e., Mexico, Guatemala, El Salvador, Honduras, Nicaragua, Costa Rica, Panama, Venezuela, Colombia, Ecuador, Peru, and the Dominican Republic). The unquestionable success of these short courses results from the organizational skills of Carlos Campabadahl (Universidad de Costa Rica). Collaboration with in-country specialists is a key to the success of INTSORMIL in collaborating countries.

Horn of Africa (Ethiopia, Eritrea, Kenya, Tanzania, Uganda)

**Gebisa Ejeta
Purdue University**

Coordinators

Gebisa Ejeta, Regional Coordinator, Purdue University, Dept. of Agronomy, West Lafayette, IN 47907

Katy Ibrahim, Administrative Assistant, IPIA, Purdue University, West Lafayette, IN 47907

Tesfaye Tesso, Ethiopia Country Coordinator, EARO, P.O. Box 2003, Addis Ababa, Ethiopia

C. K. Kamau, Kenya Country Coordinator, Katumani National Dryland Farming Research Ctr, Box 340, Machakos, Kenya

Semere Amlesom, Eritrea Country Coordinator, DARES, P.O. Box 10438, Asmara, Eritrea

Elias Letayo, Tanzania country Coordinator, Hombollo Research Station, P.O. Box 299, Dodoma, Tanzania

Critical Activities

Production and availability of improved seed continues to be a bottleneck in many of the countries in the Horn of Africa region. In each of the countries where INTSORMIL Striga resistant sorghum varieties have been officially released for wide cultivation and the integrated Striga management pilot project has aroused interest in the technology, a community based seed multiplication effort has been started. This program requires continual interaction between seed producers and collaborating research scientists. We will encourage this interaction and assist in the production and dissemination of improved seed.

Completion of a project in Uganda exploring the potential of a newly released Striga resistant sorghum cultivar for agronomic adaptation and use of the grain in local breweries has great impact potential.

Agronomic research in the areas of nutrient management, phosphorous fixation, and the collection and cataloguing of a sorghum database will be finalized during this year.

In collaboration with ECARSAM, the regional sorghum and millet program under ASARECA, INTSORMIL plans to hold a regional conference to establish a coordinated program in sorghum and millets for the region.

Southern Africa (Botswana, Mozambique, Namibia, South Africa, Zambia)

**Gary C. Peterson
Texas A&M University**

Coordinators

Dr. Medson Chisi, INTSORMIL Coordinator for SADC Region and Sorghum Breeder, Ministry of Agriculture, Crops and Soils Research, Golden Valley Research Trust, Chilanga, Zambia

Dr. Gary C. Peterson, INTSORMIL Coordinator for SADC Region and Sorghum Breeder, Texas A&M University Agricultural Research and Extension Center, Rt. 3, Box 219, Lubbock, TX 79403-9803

Collaborators

Mr. S. Awala, Pearl Millet Breeder, Omahenene Research Station, P.O. Box 646, Ombalantu, Namibia

Mr. F.P. Muuka, Pearl Millet Breeder, Ministry of Agriculture, Kaoma Res. Station, P.O. Box 940084, Kaoma, Zambia

Dr. J. Wilson, Pearl Millet Breeder, USDA-ARS, P.O. Box 748, Tifton, GA 31793

Mr. G. M. Kaula, Plant Pathologist, Private Bag 7, Mt. Makulu Research Station, Chilanga, Zambia

Ms. P. Ditshipi, Plant Pathologist, Dept. of Agricultural Research, Private Bag 0033, Gaborone, Botswana

(currently Graduate Student, University of the Free State, Bloemfontain, South Africa)

Dr. N. McLaren, Plant Pathologist, Dept. of Plant Sciences, University of the Free State, P.O. Box 339,

Bloemfontein 9300 South Africa

Dr. W. Marasas, Pathologist, Program on Mycotoxins and Experimental Carcinogenesis, Medical Research Council, P.O. Box 19070, Tygerberg 7505, South Africa

Dr. J. Leslie, Plant Pathologist, Dept. of Plant Pathology, Kansas State University, 4002 Throckmorton Plant Sciences Center, Manhattan, KS 66506-5502

Dr. J. Taylor, Cereal Quality, Dept. of Food Science, University of Pretoria, Pretoria 0002, South Africa

Dr. Janice Dewars, Research Scientist, CSIR, Pretoria, South Africa

Dr. L. Rooney, Cereal Quality, Dept. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843

Dr. H. du Plessis, Entomologist, ARC-Grain Crops Institute, Private Bag X1251, Potchefstroom 2520, South Africa

Dr. J. van den Berg, Entomologist, School of Environmental Sciences and Development, North West University (Potchefstroom Campus), Potchefstroom 2520 South Africa

Dr. David Munthali, Entomology, Botswana College of Agriculture, Private Bag 0027, Gaborone, Botswana

Mr. Fernando Chitio, Entomologist, Instituto Nacional de Investigação Agronómica, Nampula, Mozambique

Dr. Bonnie B. Pendleton, Entomologist, Division of Agriculture, West Texas A&M University, Canyon, TX 79016

Dr. Stephen Chite, Sorghum Breeder, Dept. of Agricultural Research, Francistown, Botswana

Dr. W.L. Rooney, Sorghum Breeder, Dept. of Soil and Crop Sciences, Texas A&M University, College Station, TX 77843

Mr. Soares Xerinda, Agronomist, Instituto Nacional de Investigação Agronómica, Chókué, Mozambique

Dr. Charles Wortmann, Agronomist, Dep. of Agronomy and Horticulture, University of Nebraska, Lincoln, NE 68583

The overall thrust of this project during this period has been to shift sorghum and pearl millet from subsistence crops to value added cash crops and complete the graduate training of students supported through the project. The Southern Africa Regional program is a multi-disciplinary program with the goal to understand the factors that reduce grain yield and quality of sorghum and pearl millet, to develop technology to mitigate the stress effect, and to develop end-use processing technology that will increase production on, of, and processing yield of high quality sorghum and pearl millet grain. INTSORMIL funding provides resources to support graduate training and technology transfer activities conducted in collaboration with the National Agricultural Research Programs in the areas of:

Food Quality

Role of sorghum grain quality in sorghum grain and malt lager beer brewing. Research is focused on determining the benefits of using US developed white tan-plant and high digestibility sorghum lines and it involves the M.Sc. training of two Zambian graduate students: Mr. L. Mugode and Mr. C. Ng'andwe. 2) Sorghum and pearl millet milling technology: a) Optimizing sorghum roller milling to produce meal at maximum grain extraction but of optimum quality over a wide range of sorghum grain qualities. b) Assess the effects of traditional and roller milling technologies on pearl millet meal quality, particularly with respect to nutritional value. The completion of graduate training of Mr. M. Kebakile (Botswana, Ph.D.) and Mr. S. Barrion (Namibia, M.S.) will happen this year.

Expected impacts from the student research this year include: 1) Selection of white tan plant and high digestibility sorghum lines with optimal properties for lager brewing. 2) Optimization of the sorghum roller milling process to efficiently produce meal of optimal quality. 3) Knowledge as to how milling affects the nutritional value of pearl millet and why meal produced by the traditional milling process seems to be preferred.

Pathology

Complete the screening of germplasm for sources of resistance to major diseases emphasizing tan plant white grain food type sorghums for the small Southern Africa farmer. 2) Screen for toxin production by grain mold pathogens in sorghum grain products emphasizing resistance and its role in reducing toxin level. 3) Complete the study the heritability of resistance to grain molds.

Entomology

Complete the evaluation of cultivars for adaptation, and grain quality in comparison with local commonly grown varieties. We expect to identify varieties with multiple stress resistance suitable for use by indigenous small farmers. Completion of research on stored grain insects in Mozambique will result in control recommendations for farmers.

Mycotoxins

Complete the research on Fusarium toxins on Nigerian maize, sorghum and pearl millet that parallels research already completed with aflatoxin. This study is of critical importance as sorghum production may become more important if problems associated with toxins in maize result in maize produced in marginal areas being

unsafe for human consumption. This issue directly effects food security and human well-being and should encourage planting of sorghum and pearl millet in areas where both thrive but where maize is marginal.

Economics

Baseline indicators will be developed that can measure progress through time toward achieving USAID focus areas priorities. An in-depth study of the value added supply chain for the brewing of a sorghum based beer will be completed. A potentially large market exists for a high quality sorghum beer that can compete in a market niche between the higher priced lager beers and the lower priced opaque beers but a major constraint to developing this market is a shortage of the supply of sorghum. An in-depth study of this entire value added supply chain in Tanzania and Zambia will be completed in order to identify the many linkages in the supply chain that must function in a coordinated, efficient manner to achieve success in this value added market. This study has potential for significantly increasing the demand for sorghum.

Breeding

Documentation of the genotypes with the necessary traits will be completed and the genotypes will be proposed for release as varieties in the respective countries. Interact with the energy sector in Zambia which is interested in sweet sorghums for biofuels. Develop a procedure to quickly move the genotypes into the market place. Work with NGOs (such as WVI, CARE, Harvest Help, etc) to refine and extend training programs on production and processing of sorghum and pearl millet.

West Africa (Burkina Faso, Ghana, Mali, Niger, Nigeria)

Bruce Hamaker
Purdue University

Coordinators

Issoufou Kapran, INRAN/INTSORMIL Coordinator Eastern Region, B.P. 429, Niamey, Niger
Aboubacar Touré, IER/INTSORMIL Coordinator Western Region, Sotuba Research Station, BP 262, Bamako, Mali
Bruce Hamaker, Regional Coordinator, Food Science Dept., Purdue University, West Lafayette, IN 47907
Katy Ibrahim, Administrative Assistant, Intl Programs in Agriculture, Purdue University, West Lafayette, IN 47907

Only the most critical activities have been conducted in the region during this period. These involve the transfer of selected high impact INTSORMIL-generated technologies within the region and the compilation of reports and documentation of progress and impact. Plans are being made for PIs within each country to meet in a workshop format to document and write final reports.

Niger

On farm testing for elite sorghum hybrid F1-223, midge resistant SSD-35, Striga -resistant lines (EM der, Wassa). These are well developed new and important sorghum lines. Field tours and farm days are being organized for maximal exchange with other farmers and promote the acceptance of the cultivars by farmers.

On-station conservation and on-station/on-farm seed production for elite sorghum and millet cultivars to collect and preserve needed germplasm. INRAN/Niger is a leader in seed technology and establishment of a national seed unit. This came as a result of the INTSORMIL sorghum hybrid seed project.

On-farm evaluation of soil fertility management options for millet yield increase including the use of poultry manure and modified microdose.

Countrywide evaluation and demonstration of the marketing potential for value-added sorghum and millet products using grain of existing improved sorghum and millet cultivars. This will strengthen the link between production and utilization activities.

On-farm demonstration of performance enhancing finely-ground sorghum-based rations in poultry feeding.

Mali

On-farm trials demonstrating the yield potential of the white-seeded, tan-plant Guinea type sorghum cultivars through the IER On-farm Group and NGO's (World Vision and Winrock International); evaluate value-added products and commercial utilization of these cultivars.

Increased seed of selected elite sorghum varieties for collection and preservation.

Completed on-farm facility survey and botanical insecticide (from local plant) use on millet and sorghum.

Completed short-term training in biotechnology methods in marker-assisted selection at TAMU under C. Magill's direction.

Completed the ongoing sustainability analysis (started on sorghum crop yield across years) using soil parameters.

Senegal

Seed multiplication of one promising millet variety and on-farm testing of new millet varieties for demonstration purposes. Seed multiplication of two newly released sorghum varieties and advanced yield trials of selected lines have been completed.

Complete study on the slow digestion property of sorghum-based foods for use in diabetic foods.

Ghana

Transfer of technology to farmers by conducting on-farm trials of most promising sorghum lines; on-farm testing of sorghum-groundnut rotation or cowpea rotation with 40 kg N/ha applied to sorghum.

Nigeria

Multi-locational hybrid millet yield trials for farmer demonstration.

Complete the packaging and marketing studies for tsari flour, couscous, fura, dakuwa, and weaning foods from millet and sorghum.

Burkina Faso

Demonstration trials with field days, audiovisual, and scaling up for microdose fertilization, mechanized zai (water conservation system), and integrated Striga management.

Complete grain sample characterization experiments to screen for dolo (commercial local sorghum beer). Disseminating of the new dolo container developed last year that extends dolo shelf-life from 1 to 5 days; train 100 dolo makers; and produce and disseminate 300 dolo containers.

Educational Activities



Year 27 Educational Activities

INTSORMIL gives high priority to training host country scientists who will have major responsibilities for sorghum and millet research in their home countries. Training is also provided for young U.S. scientists who plan for careers in international development work.

The most frequently used mode of training is graduate study for advanced degrees, with the students' research forming an integral part of an INTSORMIL project. During the year covered by this report, 38 students from 16 different countries were enrolled in an INTSORMIL advanced degree program. Approximately 71% of these students come from countries other than the U.S. which shows the emphasis placed on host country institutional development (Figure 1).

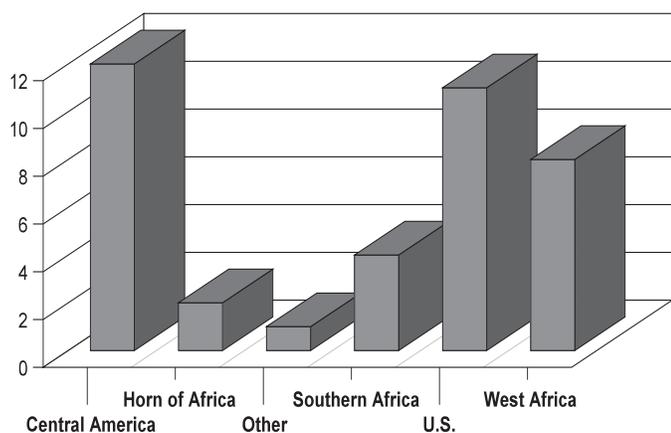


Figure 1. Degree Participants by Region

INTSORMIL also places a high priority on training women which is reflected in Figure 2. In 2005-2006, 32% of all INTSORMIL graduate participants were female. Nine of the total 38 students received full INTSORMIL scholarships. An additional 28 students received partial INTSORMIL funding and the remaining student was funded from other sources as shown in Figure 3.

All 38 students worked directly with INTSORMIL principal investigators on INTSORMIL projects. These students are enrolled in graduate programs in seven disciplinary areas, agronomy, breeding, pathology, entomology, food quality, economics, and molecular biology.

The number of INTSORMIL funded students has decreased gradually over the years. This is related to decreases in program budget and the loss of U.S. principal investigators. In 1993-94 there were 25 U.S. PIs with the program and in 2005-2006 there were 20.

Graduate degree programs and short-term training programs have been designed and implemented on a case by case basis to suit the needs of host country scientists. Two postdoctoral scientists and 11 visiting host country scientists were provided the opportunity to upgrade their skills in this fashion during 2005-2006.

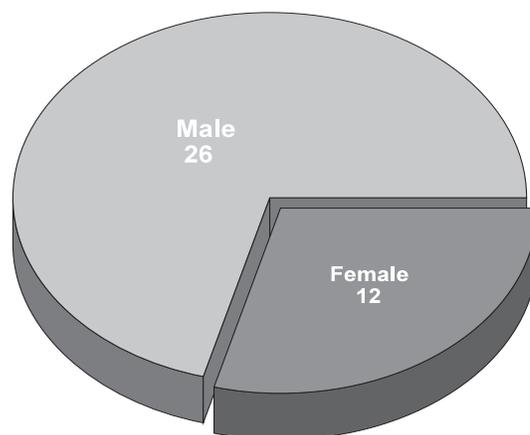


Figure 2. Degree Participants by Gender

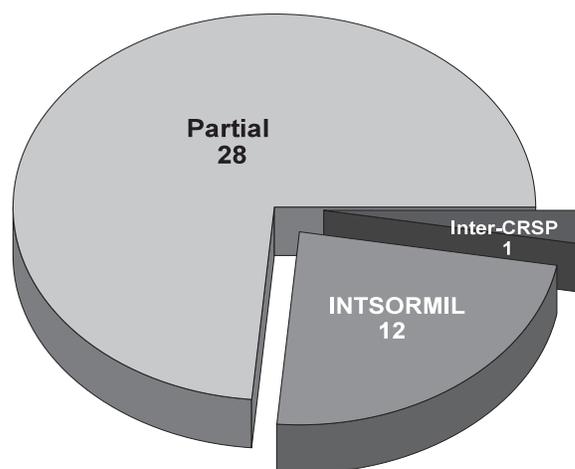


Figure 3. Degree Participants Funding

Figure 4 is a compilation of all INTSORMIL training activities by discipline for the period July 1, 2005 through June 30, 2006.

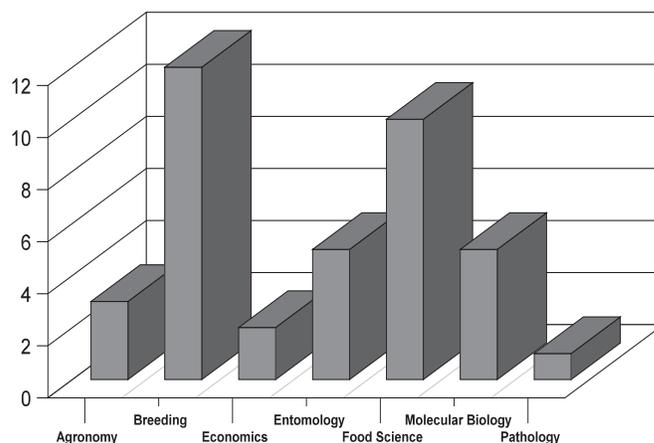


Figure 4. Degree Participants by Discipline

**Year 27 INTSORMIL Degree
Training Participants
July 1, 2005 - June 30, 2006**

Name	Country	Univ.	Discipline	Advisor	Degree	Gender	Funding
Griess, Joni	U.S.	UNL	Agronomy	Mason	MSC	F	P
Kaye Mady, Nanga	Chad	UNL	Agronomy	Mason	MSC	M	P
Abunyewa, Akwasi	Ghana	UNL	Agronomy	Wortmann/Mamo	PHD	M	P
Amusan, Idris	Nigeria	PRF	Breeding	Ejeta	MSC	M	P
Kuhlman, Les	U.S.	TAM	Breeding	W. Rooney	MSC	M	P
Mpofu, Leo	Zimbabwe	TAM	Breeding	W. Rooney	MSC	M	P
Mutaliano, Joaquim	Mozambique	TAM	Breeding	W. Rooney	MSC	M	IC
Soumana, Souley	Niger	KSU	Breeding	Tuinstra	MSC	M	I
Bading, Ryan	U.S.	TAM	Breeding	W. Rooney	PHD	M	P
Kershner, Kellen	U.S.	TAM	Breeding	Tuinstra	PHD	M	P
Knoll, Joseph	U.S.	PRF	Breeding	Ejeta	PHD	M	I
Mateo, Rafael	Honduras	TAM	Breeding	W. Rooney	PHD	M	I
Saballos, Ana	Nicaragua	PRF	Breeding	Ejeta	PHD	F	P
Teme, Niaba	Mali	TTU	Breeding	Peterson	PHD	M	I
Wordoffa, Zenbaba	Ethiopia	PRF	Breeding	Ejeta	PHD	M	P
Baquedaño, Felix	Nicaragua	PRF	Economics	Sanders	MSC	M	P
Wubeneh, Nega	Ethiopia	PRF	Economics	Sanders	PHD	M	I
Bhemappa, S.	India	WTU	Entomology	Pendleton	MSC	M	P
Telly, Madani	Mali	WTU	Entomology	Pendleton	MSC	M	P
Belete, Tebkew D.	Ethiopia	WTU	Entomology	Pendleton	PHD	M	P
Parada Jaco, Mario	El Salvador	MSU	Entomology	Pitre	PHD	M	I
Pichardo, Sergio	Nicaragua	MSU	Entomology	Pitre	PHD	M	P
Barron, Marc	U.S.	TAM	Food Science	L. Rooney/M. Riaz	MSC	M	P
Calderon, Vilma	El Salvador	TAM	Food Science	L. Rooney	MSC	F	I
Cardenas, Ana	Mexico	TAM	Food Science	L. Rooney	MSC	F	P
Guajardo, David	Mexico	TAM	Food Science	L. Rooney	MSC	M	P
Hines-Wortham, L.	U.S.	TAM	Food Science	L. Rooney	MSC	F	P
Poland, Nathan	U.S.	TAM	Food Science	L. Rooney	MSC	M	P
Austin, Dilek	U.S.	TAM	Food Science	L. Rooney	PHD	F	P
Guajardo, Sara	Mexico	TAM	Food Science	L. Rooney	PHD	F	P
Nenge, Lynda	Cameroon	TAM	Food Science	L. Rooney	PHD	F	P
Ngwenya Dlamini, N.	Zimbabwe	TAM	Food Science	L. Rooney/J. Taylor	PHD	F	P
Burns, Frederick	U.S.	TAM	Molecular Biology	Magill	MSC	M	P
Katile, Seriba	Mali	TAM	Molecular Biology	Magill	PHD	M	I
Portillo, Ostilio	Honduras	TAM	Molecular Biology	Hays	MS	M	P
Winn, Jennifer	U.S.	TAM	Molecular Biology	Hays	MS	F	P
Robbins, Adriana	Mexico	TAM	Molecular Biology	Hays	PHD	F	P
Ditshipi, Phoebe	Botswana	UFS	Pathology	McLaren/Swart	PHD	F	I

I = Completely funded by INTSORMIL

P = Partially funded by INTSORMIL

IC = InterCRSP funding

KSU = Kansas State Univ.

TAM = Texas A&M Univ.

USDA = Tifton, Georgia

MSU = Mississippi State Univ.

TTU = Texas Tech Univ.

WTU = W. Texas A&M Univ.

PRF = Purdue Univ.

UNL = Univ. of Nebraska, Lincoln

**Year 27 INTSORMIL Non-Degree
Training Participants
July 1, 2005 - June 30, 2006**

Name	Country	Univ.	Discipline	Advisor	Activity	Gender	Fundin
Gebreyesus, Brhane	Ethiopia	UNL	Agronomy	Wortmann/Mamo	VS	M	I
Kaizzi, Kayuki	Uganda	UNL	Agronomy	Wortmann/Mamo	VS	M	I
Diarisso, Niamoye	Mali	WTAMU	Entomology	Pendleton	VS	F	I
Alvarado de Torres, M.	El Salvador	TAMU	Food Sciences	L. Rooney	VS	F	I
Koreissi, Yara	Mali	TAMU	Food Sciences	L. Rooney	VS	M	P
Melendez, Herbert	Guatemala	TAMU	Food Sciences	L. Rooney	VS	M	P
Palacios, Eliette	Nicaragua	TAMU	Food Sciences	L. Rooney	VS	F	I
Diourté, Mamourou	Mali	TAMU	Molecular Biology	Magill	VS	M	I
Nutsugah, Steven	Ghana	TAMU	Molecular Biology	Magill	VS	M	P
Anderson, Laurel	U.S.	KSU	Pathology	Leslie	PD	F	P
Jurgenson, Jim	U.S.	KSU	Pathology	Leslie	VS	M	P
Lima, Cristiano	Brazil	KSU	Pathology	Leslie	VS	M	P
Saleh, Amgad	Egypt	KSU	Pathology	Leslie	PD	M	P

VS = Visiting Scientist PD = Post Doctoral

**Year 27 INTSORMIL
Conference/Workshop Activities
July 1, 2005 - June 30, 2006**

Name	Location	Date	Participants		
			Male	Female	Total
IFDC Soil Fertility Workshop	Accra, Ghana	Apr 11-15, 2005	7	0	7
Scientific Writing Workshop	Penang, Malaysia	Aug 24, 2005	95	137	232
Scientific Writing Workshop	Padang, Indonesia	Aug 29, 2005	37	30	67
Scientific Writing Workshop	Daejon, Korea	Aug 31, 2005	43	52	95
IITA Mycotoxin Conference	Accra, Ghana	Sept 13-16, 2005	3	1	4
Scientific Writing Workshop	Ibadan, Nigeria	Sept 28, 2005	70	27	97
Forage Sorghum Workshop	San Miguel, El Salvador	Nov 15-17, 2005	189	38	227
Ag Program Conference	College Station, Texas	Jan 9-11, 2006	1	0	1
Annual Meeting of the Southwestern Branch of the Entomological Society of America	Austin, Texas	Feb 27-Mar 2, 2006	2	0	2
Scientific Writing Workshop	Cuarto, Argentina	Mar 18, 2006	14	23	37
PCCMCA Meeting	Montelimar, Nicaragua	Mar 23-28, 2006	2	0	2
International Pearl Millet Improvement and Seed Production Training Course	Hyderabad, India	May 2-15, 2006	3	0	3
Fusarium Laboratory Workshop	Bari, Italy	June 4-9, 2006	22	18	40
2006 Great Plains Sorghum Conference	Manhattan, KS	Sept 6-7, 2006	1	0	1
TOTAL			482	326	808

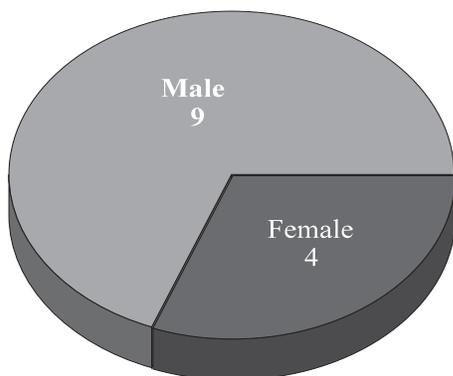


Figure 5. Total Non-Degree Participants by Gender

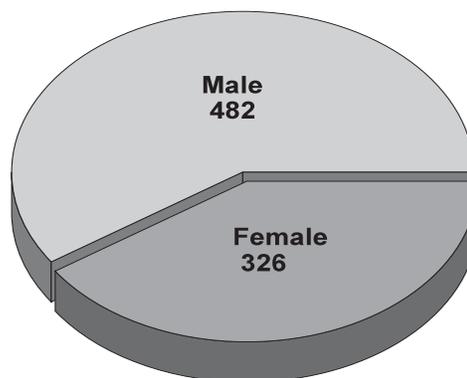


Figure 6. Total Conference/Workshop Participants by Gender

Appendices



**INTSORMIL Sponsored and
Co-Sponsored Workshops 1979 - 2006**

Name	Where	When
1. International Short Course in Host Plant Resistance	College Station, Texas	1979
2. INTSORMIL PI Conference	Lincoln, Nebraska	1/80
3. West Africa Farming Systems	West Lafayette, Indiana	5/80
4. Sorghum Disease Short Course for Latin America	Mexico	3/81
5. International Symposium on Sorghum Grain Quality	ICRISAT	10/81
6. International Symposium on Food Quality	Hyderabad, India	10/81
7. Agrimetrology of Sorghum and Millet in the Semi-Arid Tropics	ICRISAT	1982
8. Latin America Sorghum Quality Short Course	El Batan, Mexico	4/82
9. Sorghum Food Quality Workshop	El Batan, Mexico	4/82
10. Sorghum Downy Mildew Workshop	Corpus Christi, Texas	6/82
11. Plant Pathology	CIMMYT	6/82
12. <i>Striga</i> Workshop	Raleigh, North Carolina	8/82
13. INTSORMIL PI Conference	Scottsdale, Arizona	1/83
14. INTSORMIL-ICRISAT Plant Breeding Workshop	CIMMYT	4/83
15. Hybrid Sorghum Seed Workshop	Wad Medani, Sudan	11/83
16. Stalk and Root Rots	Bellagio, Italy	11/83
17. Sorghum in the 80's	ICRISAT	1984
18. Dominican Republic/Sorghum	Santo Domingo	1984
19. Sorghum Production Systems in Latin America	CIMMYT	1984
20. INTSORMIL PI Conference	Scottsdale, Arizona	1/84
21. Primer Seminario Nacional Sobre Produccion y Utilizacion del Sorgo	Santo Domingo	2/84
22. Evaluation Sorghum for A1 Toxicity in Tropical Soils of Latin America	Cali, Colombia	4/84
23. First Consultative and Review on Sorghum Research in the Philippines	Los Banos, Philippines	6/84
24. INTSORMIL Graduate Student Workshop and Tour	College Station, Texas	6/84
25. International Sorghum Entomology Workshop	College Station, Texas	7/84
26. INTSORMIL PI Conference	Lubbock, Texas	2/85
27. Niger Prime Site Workshop	Niamey, Niger	10/85
28. Sorghum Seed Production Workshop	CIMMYT	10/85
29. International Millet Conference	ICRISAT	4/86
30. INTSORMIL PI Conference	Kansas City, Missouri	1/87
31. Maicillos Criollos and Other Sorghum in Middle America Workshop	Tegucigalpa, Honduras	12/87
32. 2 nd Global Conference on Sorghum/Millet Diseases	Harare, Zimbabwe	3/88
33. 6 th Annual CLAIS Meeting	San Salvador, El Salvador	12/88
34. International INTSORMIL Research Conference	Scottsdale, Arizona	1/89
35. ARC/INTSORMIL Sorghum/Millet Workshop	Wad Medani, Sudan	11/89
36. Workshop on Sorghum Nutritional Grain Quality	West Lafayette, Indiana	2/90
37. Sorghum for the Future Workshop	Cali, Colombia	1/91
38. INTSORMIL PI Conference	Corpus Christi, Texas	7/91
39. Workshop on Social Science Research and the CRSPs	Lexington, Kentucky	2/92
40. Workshop on Adaptation of Plants to Soil Stresses	Lincoln, Nebraska	8/93
41. International Conference on Genetic Improvement of Sorghum and Millet	Lubbock, Texas	9/96
42. Conference on Ergot of Sorghum in the Americas	Sete Lagos, Brazil	6/97
43. Ethiopia Sorghum and Millet Traveling Workshop	Ethiopia	9/97
44. Mali Sorghum Characterization Workshop	Cinzana, Mali	11/97
45. INTSORMIL PI Conference	Corpus Christi, Texas	6/98
46. Impact Assessment Workshop	Corpus Christi, Texas	6/98
47. Conference on the Status of Sorghum Ergot in North America	Corpus Christi, Texas	6/98
48. Regional Hybrid Sorghum and Pearl Millet Seed Workshop	Niamey, Niger	9/98
49. CRSP Symposium/Annual Meeting of the American Society of Agronomy	Baltimore, Maryland	10/98
50. Global 2000 Sorghum and Pearl Millet Diseases III	Guanajuato, Mexico	9/00
51. INTSORMIL PI Conference	Addis Ababa, Ethiopia	11/02
52. West Africa Regional Meeting	Ougadougou, Burkina Faso	04/04
53. South Africa White Sorghum Workshop	Univ. of Pretoria, South Africa	09/04
54. Marketing & Processing for Dryland Crops in West Africa	Bamako, Mali	11/04
55. Marketing & Processing for Dryland Crops in West Africa	Saly, Senegal	12/05
56. West Africa Regional Meeting	Ouagadougou, Burkina Faso	03/06
57. Southern Africa Regional Sorghum Breeders Workshop	Lusaka, Zambia	04/06

Acronyms

AAA/SFAA	American Anthropological Association/Society for Applied Anthropology
ABA	Abscisic Acid
ADC's	Advanced Developing Countries
ADIN	All Disease and Insect Nursery
ADRA	Adventist Development and Relief Agency
AFLP	Amplified Fragment Length Polymorphisms
AID	Agency for International Development
AID/H	Agency for International Development in Honduras
ALDEP	Arable Lands Development Program
AMEDD	Association Malienne d'Eveil Au Développement
ANOVA	Analysis of Variance
ANPROSOR	Nicaraguan Grain Sorghum Producers Association
APHIS	Animal and Plant Health Inspection Service, U.S.
ARC	Agricultural Research Corporation, Sudan
ARC	Agriculture Research Council, South Africa
ARGN	Anthraxnose Resistant Germplasm Nursery
ARS	Agricultural Research Service
ASA	American Society of Agronomy
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
ATIP	Agricultural Technology Improvement Project
AVES	Asociación de Avicultores de El Salvador
BAMB	Botswana Agricultural Marketing Board
BIFAD	Board for International Food and Agricultural Development
BFTC	Botswana Food Technology Centre
CARE	Cooperative for American Remittances to Europe, Inc.
CARO	Chief Agricultural Research Officer
CARS	Central Agricultural Research Station, Kenya

Appendices

CATIE	Centro Agronómico Tropical de Investigación y Enseñanza, Costa Rica
CEDA	Centro de Enseñanza y Adiestramiento, SRN, Honduras
CEDIA	Agricultural Document and Information Center, Honduras
CENTA	Centro Nacional de Tecnología Agropecuaria y Forestal, El Salvador
CFTRI	Central Food Technological Research Institute, India
CGIAR	Consultative Group on International Agricultural Research
CIAB	Agricultural Research Center of the Lowlands, Mexico
CICP	Consortium for International Crop Protection
CIDA	Canadian International Development Agency
CIAT	International Center for Tropical Agriculture, Colombia
CILSS	Interstate Committee to Combat Drought in the Sahel
CIMAR	Centro de Investigación en Ciencias del Mar y Limnología, Costa Rica
CIMMYT	International Maize and Wheat Improvement Center
CIRAD	Centre International en recherche Agronomique pour le Développement
CITESGRAN	Centro Internacional de Tecnología de Semilla y Granos, EAP in Honduras
CLAIS	Comisión Latinoamericana de Investigadores en Sorgo
CMS	Cytoplasmic Male-Sterility System
CNIA	Centro Nacional de Investigaciones Agrícolas, Nicaragua
CNPQ	Conselho Nacional de Desenvolvimento Científico e Tecnológico
CNRA	National Center for Agricultural Research, Senegal
CORASUR	Consolidated Agrarian Reform in the South, Belgium
CRSP	Collaborative Research Support Program
CSIR	Council for Scientific and Industrial Research
CSIRO	Commonwealth Scientific and Industrial Research Organization, Australia
DAR	Department of Agricultural Research, Botswana
DARE	Division of Agricultural Research and Extension, Eritrea
DICTA	Dirección de Ciencia y Tecnología Agrícola, Mexico
DR	Dominican Republic
DRA	Division de la Recherche Agronomique, IER Mali

Appendices

DRI-Yoro	Integrated Rural Development Project, Honduras-Switzerland
EAGA	Extended Agar Gel Assay
EAP	Escuela Agrícola Panamericana, Honduras
EAVN	Extended Anthracnose Virulence Nursery
EIAR	Ethiopian Institute for Agricultural Research
EWA	Austrian NGO
ECARSAM	East Central Africa Regional Sorghum and Millet
ECHO	Educational Concerns for Hunger Organization
EEC	European Economic Community
EEP	External Evaluation Panel
EIME	Ensayo Internacional de los Maicillos Enanos
ELISA	Enzyme-linked Immunosorbent Assay
EMBRAPA	Empresa Brasileira de Pesquisa Agropecuária, Brazil
EMBRAPA-CNPMS	EMBRAPA - Centro Nacional para Maize e Sorgo
ENA	National School of Agriculture, Honduras
EPIC	Erosion Productivity Impact Calculator
ERS/IEC	Economic Research Service/International Economic Development
ESBESA	Escobar Betancourt S.A.
EZC	Ecogeographic Zone Council
FAO	Food and Agriculture Organization of the United States
FDS	Fonds de Développement pour la Solidarité
FENALCE	Federación Nacional de Cultivadores de Cereales
FHIA	Fundación Hondureña de Investigación Agrícola, Honduras
FPX	Federation of Agricultural and Agro-Industrial Producers and Exporters
FSR	Farming Systems Research
FSR/E	Farming Systems Research/Extension
FUNDESYRAM	Fundación Para E Desarrollo Socio-Económico y Restauración Ambiental
FUNPROCOOP	Fundación Promotora de Coopertivas
GASGA	Group for Assistance on Systems Relating to Grain after Harvest

GMB	Grain Marketing Board
GOB	Government of Botswana
GOH	Government of Honduras
GRADECOM	Groupe de Recherche et d'Action pour le Développement Communautaires
GTZ	German Agency for Technical Cooperation
GWT	Uniform Nursery for Grain Mold
HIAH	Honduran Institute of Anthropology and History
HOA	Horn of Africa
HPLC	High Pressur Liquid Chromatography
HR	Hypersensitive Response
IAN	Institute Agronomia Nacional, Paraguay
IANR	Institute of Agriculture and Natural Resources, University of Nebraska, Lincoln
IARC	International Agriculture Research Center
IBSNAT	International Benchmark Soils Network for Agrotechnology Transfer
ICA	Instituto Colombiano Agropecuario/Colombian Agricultural Institute
ICAR	Indian Council of Agricultural Research
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICC	International Association for Cereal Chemistry
ICRISAT	International Crops Research Institute for the Semi-arid Tropics
ICTA	Instituto de Ciencias y Tecnologia Agrícolas, Guatemala
IDIAP	Agricultural Research Institute of Panama
IDIN	International Disease and Insect Nursery
IDRC	International Development Research Center
IER	Institute of Rural Economy, Mali
IFAD	International Fund for Agricultural Development, Rome
IFPRI	International Food Policy Research Institute
IFSAT	International Food Sorghum Adaptation Trial
IGAD	Intergovernmental Authority on Development
IHAH	Instituto Hondureño de Antropología e Historia

IICA	Instituto Interamericano de Cooperación para la Agricultura
IIMYT	International Improved Maicillo Yield Trial
IITA	International Institute of Tropical Agricultura
ILRA	International Livestock Research Institute, Niger
INCAP	Instituto de Nutrición de Centro America y Panama
INERA	Institut d'Environnement et de Recherche Agricoles
INFOP	National Institute for Professional Development
INIA	Instituto Nacional de Investigaciones Agrícolas, Mexico
INIAP	National Agricultural Research Institute, Ecuador
INIFAP	Instituto Nacional de Investigaciones Forestales y Agropecuarias, Mexico
INIPA	National Agricultural Research Institute, Peru
INRAN	Institut National de Recherches Agronomiques du Niger
INTA	Instituto Nicaragüense de Tecnología Agropecuaria, Nicaragua
INTSORMIL	International Sorghum/Millet, Collaborative Research Support Program (CRSP)
IPA	Instituto de Pesquisas Agronómicas, Brazil
IPIA	International Programs in Agriculture, Purdue University
IPM	Integrated Pest Management
IPR	Intellectual Property Rights
IRAT	Institute of Tropical Agriculture and Food Crop Research
IRRI	International Rice Research Institute, Philippines
ISAVN	International Sorghum Anthracnose Virulence Nursery
ISC	ICRISAT Sahelian Center
ISM	Integrated Striga Management
ISRA	Institute of Agricultural Research, Senegal
ISVN	International Sorghum Virus Nursery
ITA	Institut de Technologie Alimentaire, Senegal
ITAT	International Tropical Adaptation Trials
ITESM	Monterrey Institute of Technology, Mexico
ITVAN	International Tall Variety Adaptation Nursery

JCARD	Joint Committee on Agricultural Research and Development
KARI	Kenya Agriculture Research Institute
KIRDI	Kenya Industrial Research and Development Institute
KSU	Kansas State University
LASIP	Latin American Sorghum Improvement Project, Mexico
LC/MS	Liquid Chromatography/Mass Spectrometry
LCRI	Lake Chad Research Institute
LDC	Less Developed Country
LIDA	Low Input Dryland Agriculture
LIFE	League for International Food Education
LUPE	Land Use and Productivity Enhancement
LWMP	Land and Water Management Project
MAFES	Mississippi Agricultural and Forestry Experiment Station
MAVS	Ministerio de Agricultura y Ganadería
MC	Maicillo Criollo
ME	Management Entity
MFC	Mechanized Farming Corporation, Sudan
MHM	Millet Head Miner
MIAC	Mid-America International Agricultural Consortium
MIPH	Honduran Integrated Pest Management Project
MNR	Ministry of Natural Resources, Honduras
MOA	Memorandum of Agreement
MOA	Ministry of Agriculture, Botswana
MOALD	Ministry of Agriculture and Livestock Development, Kenya
MOU	Memorandum of Understanding
MRN	Ministerio de Recursos Naturales, Honduras
MSU	Mississippi State University
NAARP	Niger Applied Agricultural Research Project
NARO	National Agricultural Research Organization, Uganda

NARP	National Agricultural Research Project
NARS	National Agricultural Research System
NCRP	Niger Cereals Research Project
NGO	Non-Government Organization
NSF	National Science Foundation
NSP	National Sorghum Program
NSSL	National Seed Storage Laboratory, Fort Collins, CO
NU	University of Nebraska
OAS	Organization of American States
OAU	Organization of African Unity
OFDA	Office of Foreign Disaster
OICD	Office of International Cooperation and Development
ORSTOM	L'Institut Français de Recherche Scientifique pour le Développement en Coopération, France
PCCMCA	Programa Cooperative Centroamericano para el Mejoramiento de Cultivos Alimenticios
PI	Principal Investigator
PL480	Public Law No. 480
PNVA	Malien Agricultural Extension Service
PPRI/DRSS	Plant Protection Research Institute/Department of Research and Specialist Services
PRF	Purdue Research Foundation
PRIAG	Regional Program to Strengthen Agronomical Research on Basic Grains in Central America
PRODAP	Proyecto de Desarrollo Rural en la Región Paracentral
PROMECA	Program for Research on Mycotoxicology and Experimental Carcinogenesis, South African Medical Research Council
PROFIT	Productive Rotations on Farms in Texas
PROMESA	Proyecto de Mejoramiento de Semilla - Nicaragua
PSTC	Program in Science and Technology Cooperation
PVO	Private Volunteer Organization
QTL	Quantitative Trait Loci
QUEFTS	Quantitative Evaluation of the Fertility of Tropical Soils

RADRSN	Regional Advanced Disease Resistance Screening Nursery
RAPD	Random Amplified Polymorphic DNA
RARSN	Regional Anthracnose Resistance Screening Nursery
RFA	Request for Assistance
RFLP	Restriction Fragment Length Polymorphism
RFP	Request for Proposals
RI	Recombinant Inbred
RIIC	Rural Industry Innovation Centre, Botswana
RPDRSN	Regional Preliminary Disease Resistance Screening Nursery
RVL	Royal Veterinary and Agricultural University, Frederiksberg, Denmark
SACCAR	Southern African Centre for Cooperation in Agricultural Research
SADC	Southern Africa Development Community
SAFGRAD	Semi-Arid Food Grains Research and Development Project
SANREM	Sustainable Agriculture and Natural Resource Management CRSP
SARI	Savannah Agricultural Research Institute, Ghana
SAT	Semi-Arid Tropics
SDM	Sorghum Downy Mildew
SDMVN	Sorghum Downy Mildew Virulent Nursery
SICNA	Sorghum Improvement Conference of North America
SIDA	Swedish International Development Agency
SMIP	Sorghum and Millet Improvement Program
SMINET	Sorghum and Millet Improvement Network
SPARC	Strengthening Research Planning and Research on Commodities Project, Mali
SRVCO	Section of Food Crops Research, Mali
SRN	Secretaria de Recursos Naturales, Honduras
TAES	Texas Agricultural Experiment Station
TAMU	Texas A&M University
TARS	Tropical Agriculture Research Station
TC	Technical Committee

TPHT	Tan Plant Hybrid Trial
TropSoils	Tropical Soils Collaborative Research Program, CRSP
UANL	Universidad Autónoma de Nuevo Leon, Mexico
UHSN	Uniform Head Smut Nursery
UNA	Universidad Nacional Agraria, Nicaragua
UNAN	Universidad Nacional Autónoma de Nicaragua, Leon, Nicaragua
UNILLANOS	Universidad Tecnológica de los Llanos
UNL	University of Nebraska, Lincoln
UPANIC	Union of Agricultural Producers of Nicaragua
USA	United States of America
USAID	United States Agency for International Development
USAID-RAPID	Regional Activity to Promote Integration through Dialogue and Policy Implementation
USDA	United States Department of Agriculture
USDA/TARS	United States Department of Agriculture/Tropical Agriculture Research Station
VCG	Vegetative Compatibility Group
WASAT	West African Semi-Arid Tropics
WASDON	West Africa Sorghum Disease Observation Nursery
WASIP	West Africa Sorghum Improvement Program
WCAMRN	West and Central African Millet Research Network (ROCAFREMI), Mali
WCASRN	West and Central African Sorghum Research Network (ROCARS), Mali
WVI	World Vision International

**Residents of Tajaé, Niger Display Sorghum, Grown for Seed
Grain, Stored in the Village Storehouse**

Photo by: Simon Tripp, Battelle



USAID
FROM THE AMERICAN PEOPLE