

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, CREAM 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 Neya, 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, Chilanga, 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