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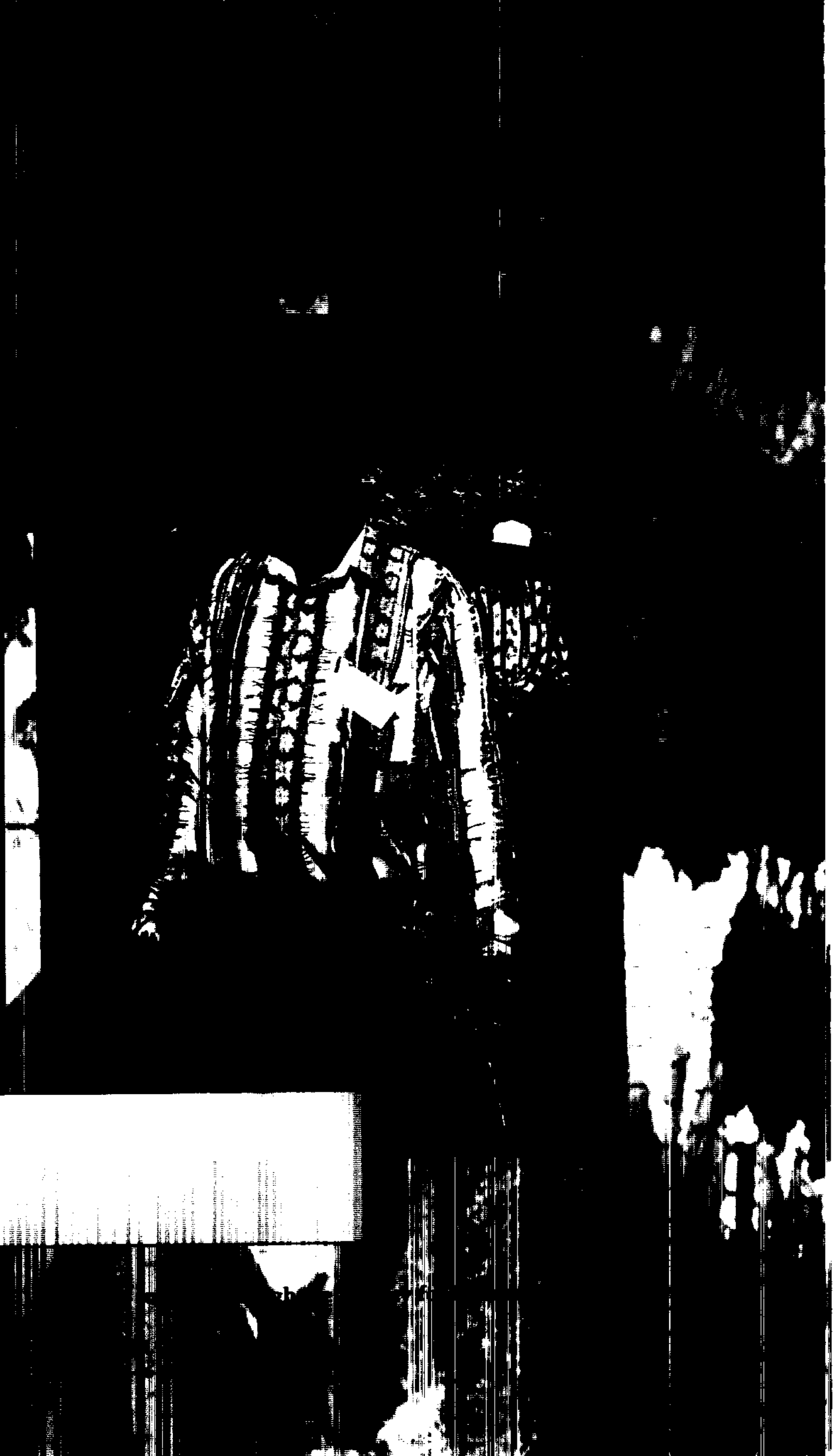
2001 Annual Report



Peter Esele earned his Ph.D. degree in plant pathology at Texas A&M University in 1991. As a sorghum and millet pathologist, Dr. Esele has conducted research on grain molds, Anthracnose in sorghum, and blast in finger millet at Uganda's Serere Agricultural Research Institute from 1981 to 2001. He served as Director of Research at Serere Agricultural Research Institute from 1992 to 2000 and was elected member of the Parliament of Uganda in July, 2001. Dr. Esele has been a collaborating research scientist in INTSORMIL since 1983 in sorghum and pearl millet research.

INTSORMIL

2001 Annual Report

Executive Summary

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

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

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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

University of Illinois, Urbana - Champaign
Kansas State University
Mississippi State University
University of Nebraska - Lincoln
Purdue University
Texas A&M University
USDA-ARS, Tifton, Georgia

INTSORMIL Institutions are affirmative action/equal opportunity institutions.

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Introduction and Program Overview

Presently, worldwide, more than 800 million people are hungry and over one billion are desperately poor, and food demand is increasing rapidly. The majority of poor live in rural areas in developing countries and agricultural and food systems development is vital to economic growth; improving environmental quality; strengthening nutrition, health and child survival; improving the status of women; and promoting democratization. It is estimated that, between 1980 and 2030, the population of low- and middle-income countries will more than double–to seven billion, compared with one billion for high-income countries. In the next 35 years, 2.5 billion people will be added to the current population of 6 billion. More than 1.3 billion people today live on less than one dollar per day, and it is estimated that the number of hungry people will exceed one billion by 2020. The global population of underweight children below age five is expected to increase from 193 million in Year 2000 to over 200 million in Year 2020. *Increased production of cereals, which are crucial sources of food energy and other nutrients, is necessary to reduce world hunger.*

According to *Entering the 21st Century–World Development Report 1999-2000*, about 900 million people in almost 100 countries are affected by drought and desertification, and by 2025, that number will double. The population of the world has doubled since 1940, but fresh water use has increased fourfold. Water scarcity is becoming more widespread, with concomitant effects on regional peace and global food security. Nearly all of the three billion increase in global population which is expected by 2025 will be in developing countries where water is already scarce. To meet the increasing demand for food in those countries, there is an increasing demand for more efficient production and new ways of utilizing drought-tolerant crops which have a competitive advantage to produce food under conditions of unpredictable and scarce rainfall. As water becomes more precious in the United States, cereals which can produce energy for feed and fuel in drought-prone areas of the country are demonstrating increasingly competitive advantages.

In developing countries of the semi-arid regions *sorghum and millet*, two important cereal grains, make the difference between food security and famine. In the United States, sorghum is important to the balance of trade, is an important feed in the production of beef, and is increasingly in demand as a raw material for food and as a renewable feedstock for production of fuel. In 2000, 58.5 Tg (million tons) of sorghum were produced world wide, of which 18.6 Tg were produced in Africa, mainly for direct consumption by humans, and 11.9 Tg were produced in the United States, mainly for livestock feed to produce meat for human consumption. In 1999, the United States exported 5.9 Tg of grain sorghum mainly for livestock feed, and in 1999, U.S. grain sorghum exports were worth $555 million. Large areas are planted to sorghum each year. For example, in 2000 sorghum was produced on 42.1 million hectares (ha, or 162,549 square miles, [sq mi]) worldwide, 21.6 million ha (83,398 sq mi) in Africa, and 3.1 million ha (11,969 sq mi) in the United States. About 500 million people worldwide depend upon sorghum for food, and most of these people are in developing countries where droughts and famine are common occurrences. *Clearly, sorghum production and utilization as food and feed are vitally important to developing countries and to the United States.*

Millets, which include several types such as pearl millet, finger millet and proso millet, are cereal crops even better adapted to arid ecosystems than is sorghum, and pearl millet is a staple for 300 million people worldwide. Most of these people are in countries within semi-arid regions where malnourishment is a persistent problem. In 2000, 36.0 million hectares (138,997 sq mi) of millets were harvested worldwide, of which 20.1 million ha (77,606 sq mi) were harvested in Africa, and 149,740 ha (578 sq mi) were harvested in the United States. In 2000, the amount of millets harvested worldwide was 27.2 Tg, of which 13.5 Tg were harvested in Africa and 166,000 Mg (thousand tons) were harvested in the United States. Millets are crops used mainly for direct consumption by humans in developing countries, and the millets are used mainly for feeding livestock, particularly poultry, in developed countries. Pearl millet is an important cereal crop which provides food energy and other nutrients to hundreds of millions of people in areas which currently suffer from malnutrition, particularly Africa and southern Asia. *The United States and all other participants in the World Food Conference have a stake in promoting the production and utilization of sorghum and pearl millet to help end hunger, particularly in Africa.*

In October 1999, the International Food Policy Research Institute (IFPRI) noted that in both developed and developing countries, the rate of increase in cereal yields is slowing from the days of the Green Revolution, partly due to reduced use of inputs like fertilizer and partly due to low levels of investment in agricultural research and technology. In *World Food Prospects: Critical Isssues for the Early Twenty-First Century*, IFPRI points out that "without substantial and sustained additional investment in agricultural research and associated factors, it will become more and more difficult to maintain, let alone increase, cereal yields in the longer term. The gap in average cereal yields between the developed and developing countries is slowly beginning to narrow, but it is widening considerably within the developing world as Sub-Saharan Africa lags further and further behind the other regions . . . ." In its *2020 Global Food Outlook Report*, IFPRI observes that "Cultivating more and more land will not solve Sub-Saharan Africa's food security problems for the long-term. Between 1967 and 1997, the re-

gion expanded cereal cultivation by 31 million hectares and roots and tubers cultivation by 8 million hectares. This rate of expansion is not sustainable; therefore, higher crop yields are needed to reduce malnutrition in Africa."

Agricultural research provides benefits not only to producers of agricultural products but also to processors and consumers of agricultural products. Agricultural research has proven itself continuously as providing improvements which yield products of greater quantity and quality, as well as improved health to consumers and broad-based economic growth which goes beyond producers and consumers. In the *U.S. Action Plan on Food Security – Solutions to Hunger,* published in March 1999, the United States government states that one of the ways that the United States plans to contribute to the global effort to reduce hunger is by the United States' continuing commitment to support international agricultural research through the Collaborative Research Support Programs.

The Collaborative Research Support Program (CRSP) concept was created by the U.S. Agency for International Development (USAID) and the Board for International Food and Agriculture Development (BIFAD), under the auspices of Title XII of the Foreign Assistance Act, as a long term mechanism for mobilizing the U.S. Land Grant Universities in the international food and agricultural research mandate of the U.S. Government. As amended in 2000, Title XII assures a wider inclusion of organizations by including land grant universities, other universities, and their public and private partners in the U.S. and other countries. The CRSPs are communities of U.S. Land Grant Universities and other universities working with USAID and other U.S. Federal Agencies, strengthening and enhancing National Agricultural Research Systems (NARS), collaborating country colleges and universities. The CRSPs also work closely with the International Agricultural Research Centers IARCs), private agencies, industry, and private voluntary organizations (PVOs) fulfilling their mandate. The Sorghum and Millet Collaborative Research Support Program is one of nine CRSPs currently in operation.

INTSORMIL's vision for 2001-2006 is to focus research of multidisciplinary, international teams of scientists to serve the economic and nutritional needs of the human populations which depend on sorghum and pearl millet for food and feed when the lack of water limits food and feed production. These teams will work on a regional basis to develop the technology to improve the economic well-being, nutrition, and health of people in both developing countries and the United States. Thus, the Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP) conducts collaborative research using partnerships between 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 and utilization for the mutual benefit of the U.S. and Less Developed Countries (LDCs).*** Collaborating scientists in NARS 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, southern, and eastern Africa, and in Central America. INTSORMIL focuses resources on prime sites 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 and utilization. INTSORMIL's activities are aimed at achieving sustainable, global impact, promoting economic growth, enhancing food security, and encouraging entrepreneurial activities. The six universities currently active in the INTSORMIL CRSP are the University of Illinois, Kansas State University, Mississippi State University, University of Nebraska, Purdue University, and Texas A&M University. In addition, scientists of the Agricultural Research Service of the U.S. Department of Agriculture at Tifton, Georgia participate in INTSORMIL. What were formerly referred to as "host" countries are now referred to as "collaborating" countries to indicate the closer and more collaborative relationships that have developed between the United States and those countries as a result of all that has been accomplished during the past twenty-two years of the INTSORMIL CRSP.

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, and, in their area of adaptation, sorghum and millet have a distinctly competitive advantage to yield more grain than other cereals. As wheat and rice products have been introduced to urban populations in developing countries, traditional types of sorghum, because of some quality characteristics, have not been able to effectively compete with wheat and rice products. However, as a result of research by INTSORMIL researchers and others, improved, food-quality sorghums produce grain that can be used for special ethnic and dietary products as well as for traditional food products. Special white sorghums developed by INTSORMIL collaborative research in Mali have improved characteristics which allow preparation of high-value food products made of as much as 100% sorghum which can compete successfully with wheat and rice products in village and urban markets. Couscous made from food-quality, hybrid sorghum is being market tested in Niger. The development of both open-pollinated and hybrid sorghums for food and feed with improved properties such as increased digestibility and reduced tannin content has contributed to sorghum becoming a major feed grain in the U.S. and in South America. Pearl millet is also becoming an important feed source in poultry feeds in the southeastern United States. Improved varieties and hybrids of pearl mil-

let, like improved lines of sorghum, can be grown in developing countries, as well as the United States, and have great potential for processing into high-value food products which can be sold in villages and urban markets, competing successfully with imported wheat and rice products. These developments 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 improvement and production of sorghum and millet in the regions of developing countries which INTSORMIL serves, population growth rates continue to exceed rates of increase of cereal production capacity. There remains an urgent need to continue the momentum of our successes in crop improvement, improved processing of sorghum and millet, and strengthening the capabilities of NARS scientists to do research on constraints to production and utilization of sorghum and millet.

INTSORMIL maintains a flexible approach to accomplishing its mission. The success of the INTSORMIL program 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 do research on sorghum and millet, development of collaborative research networks, promoting and linking to technology transfer and dissemination of technologies developed by research, and enhancing national, regional, and global communication linkages. A major innovative aspect of the INTSORMIL focus 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 of 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. *From a strategic standpoint, the education of agricultural scientists of developing-country scientists by INTSORMIL contributes to the economic and political stability of developing countries, through cultural ties and long-term scientific collaboration. These scientist-to-scientist bonds help enable the collaborating countries to achieve economic growth necessary to becoming more significant trading partners with their neighbors and the United States. Strategically for the United States, it is crucial to maintain a cadre of scientists knowledgeable about sorghum and millet both within and outside the United States to assure the safety and growth of these two crops in the United States, since both crops are native to Africa.*

- **Conserving biodiversity and natural resources**: Research results of the collaborative research teams include development and release of enhanced germplasm, development and improvement of sustainable production systems, development of sustainable technologies to conserve biodiversity and natural resources and to enhance society's quality of life and to enlarge the range of agricultural and environmental choices. Thus, INTSORMIL promotes conservation of millet and sorghum germplasm, promotes natural control of arthropod pests and diseases of sorghum and millet, and develops resource-efficient cropping systems. Moreover, INSORMIL develops integrated pest management programs, develops cultivars with improved nutrient and water use efficiencies, and evaluates 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 U.S. and NARS multi-disciplinary research teams 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 and improved health. New technologies developed by INTSORMIL collaborative research are extended to farmers' fields 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 by 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 existing 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 produc-

tion schemes, private and public seed programs, agricultural product supply businesses, and nonprofit voluntary 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.

- **Promoting demand-driven processes**: INTSORMIL economic analyses focus on prioritization of research, farm-level industry evaluation, development of sustainable food technology, processing and marketing systems, all of which are driven by the need for stable markets for the LDC farmer. INTSORMIL seeks alternate food uses and new processing technologies to save labor and time required in preparation of sorghum or millet for food. Research products transferred to the farm will spur rural economic growth and provide direct economic benefits to consumers. INTSORMIL assesses consumption shifts and socioeconomic policies to reduce effects of price collapses, and does research to improve processing to yield 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. 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 agricultural production technology development for the developing world, especially in the semi-arid tropics. 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 the ownership of their development strategies, while at the same time resulting in significant benefits back 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) is 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 for the 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, support 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.

Several major decisions, events and accomplishments of INTSORMIL during the past year occurred in the United States and collaborating countries.

- Dr. John Axtell, sorghum breeder at Purdue University, passed away.
- Dr. George Teetes, entomologist at Texas A&M University retired.
- Dr. Richard Fredriksen, plant pathologist at Texas A&M University, retired.
- Dr. Jerry Maranville, plant physiologist at the University of Nebraska, retired.
- Dr. Darrell Nelson, Board Member from the University of Nebraska, was elected President of the American Society of Agronomy.
- Dr. Frank Gilstrap replaced Dr. Bobby Eddleman as Board Member from Texas A&M University.
- Dr. Stephen Mason, agronomist at the University of Nebraska, received the 2000 L.K. Crowe Outstanding Undergraduate Advising Award.

The 2000-2001 Technical Committee was elected. Its members are:

- Dr. Gary Peterson, Chair, Texas A&M University (Southern Africa Regional Program Coordinator)
- Dr. John Sanders, Vice Chair, Purdue University (Agronomy/Physiology)
- Dr. Henry Pitre, Secretary, Mississippi State University (Plant Protection)
- Dr. Bruce Hamaker, Purdue University (Economics/Utilization)
- Dr. Gebisa Ejeta, Purdue University (Horn of Africa Regional Program Coordinator)
- Dr. Wayne Hanna, USDA-ARS (Plant Breeding)

- Dr. Stephen Mason, University of Nebraska (Central America Regional Coordinator)
- Dr. Aboubacar Touré, Institut de Economie Rurale, (Mali Coordinator)
- Dr. Peter Esele (Uganda Coordinator).
- INTSORMIL, INIFAP, ICRISAT and other sponsors held the Global 2000 Conference, Sorghum and Pearl Millet Diseases III, in Guanajuato, Mexico, September 23 - 30, 2000.
- INTSORMIL and the Institut Senegalais de Recherches Agricoles (ISRA), the national agricultural research system of Senegal, signed a Memorandum of Understanding, providing the institutional framework to strengthen INTSORMIL collaborative research in Senegal.
- The INTSORMIL External Evaluation Panel completed the five-year, in-depth program review.
- The INTSORMIL Five-Year Grant Extension Proposal was completed and submitted to USAID.
- INTSORMIL made its presentation for a five-year grant extension and was recommended for continuation, March, 2001.
- INTSORMIL completed negotiations with USAID/Mozambique, resulting in a grant being awarded to fund graduate education of ten Mozambican agricultural scientists by a number of CRSPs; INTSORMIL was selected by the CRSP directors to manage the graduate education program.
- The U.S. Southern Africa Regional Coordinator and the INTSORMIL Associate Program Director attended the 15th Sorghum and Millet Improvement Program (SMIP) Steering Committee Meeting at ICRISAT/Matopos, Zimbabwe, October 4-5, 2000 and visited collaborating scientists in Namibia, Zambia, Mozambique and Zimbabwe.
- INTSORMIL investigators, the Program Director and the Associate Program Director attended the annual meeting of the American Society of Agronomy and presented papers regarding INTSORMIL collaborative research, November 5 - 9, 2000.
- The Program Director and the Associate Program Director represented INTSORMIL at the meeting of the CRSP Council Steering Committee, Otter Rock, Oregon, July 23-25, 2000.
- The Associate Program Director represented the nine CRSPs at the National Stakeholders' Workshop on Rural Development Sector Strategy for Nigeria in Abuja, Nigeria, February 1 - 3, 2001
- INTSORMIL contributed to an exhibit on the nine CRSPs presented at the Fourth Annual Agricultural Research and Education Exhibition and Capitol Hill Reception in Washington, D.C., March 6, 2001. The Program Director and Associate Program Director represented INTSORMIL.

The major publications organized and published by the ME office during the year included:

- INTSORMIL 2000 Annual Report, INTSORMIL Publication 00 -1
- INTSORMIL 2000 Annual Report Executive Summary, INTSORMIL Publication 00 - 2
- Sanders, J. and D. McMillan. Agricultural Technology for the Semiarid African Horn–Country Studies. INTSORMIL Publication 00 - 3
- "Inside INTSORMIL" Newsletter, January 2001, INTSORMIL Publication 01 -1
- INTSORMIL Policy and Operating Procedures Manual, INTSORMIL Publication 01 - 2
- Lowenberg-DeBoer, J. and T. Sullivan. Feasibility Study on the Use of Sorghum and Millets in Animal Feeds–Study Tour, Kenya, Ghana, Mali and Senegal. INTSORMIL Publication 01 - 3
- Sanders, J. and D. McMillan. Agricultural Technology for the Semiarid African Horn–Synthesis and Country Studies, revised. INTSORMIL Publication 01 - 4

Education

Within INTSORMIL's regions of collaborative research and the United States, education of collaborating scientists contributes to the capability of each collaborating country research program to stay abreast of economic and ecological changes which alter the balance of sustainable production systems. The strengthening of collaborating country research institutions contributes to their capability to predict and be prepared to meet the challenges of economic and ecological changes which affect production and utilization of sorghum and millet. A well balanced agricultural research institution must prioritize and blend its operational efforts to conserve and efficiently utilize its natural resources while meeting economic needs of the population in general and the nutritional needs of both humans and livestock. To this end, education is an extremely valuable component of development assistance.

Year 22 Education (July 1, 2000 - June 30, 2001)

During Year 22, 2000-2001, there were 33 students from 17 different countries enrolled in an INTSORMIL advanced degree program and advised by an INTSORMIL principal investigator. Approximately 51% of these students came from countries other than the USA. The number of students receiving 100% funding by INTSORMIL in 2000-2001 totaled 13. An additional 20 students received partial funding from INTSORMIL.

Conferences and workshops are an important means of continuing education for scientists doing research on sorghum and millet. During Year 22, INTSORMIL supported several workshops, the largest of which was Global 2000: Sorghum and Pearl Millet Diseases III at Guanajuato, Mexico, September 23-30, 2000. One hundred thirty participants from twenty-two countries attended the workshop at which they learned about worldwide state-of-the-art research on diseases of sorghum and pearl millet. One individual participated in the ROCARS Mid-Term Network Evaluation in Mali, West Africa. In addition, a number of scientific writing workshops were offered by an INTSORMIL PI in Manhattan, KS, South Africa, Mali, Malaysia, Egypt, and Uganda. About 330 individuals improved their scientific writing skills by participating in these workshops. Another benefit of the conferences and workshops sponsored by INTSORMIL is that they increase the sharing of information, a key factor in developing more efficient research strategies and in more efficiently carrying out research. Of the participants at these conferences and workshops, INTSORMIL funded 60 and provided partial funding for the participation of 419.

Another important category of education which INTSORMIL supports is non-degree research activities, namely post-doctoral research and research of visiting scientists with INTSORMIL PI's in the United States. During Year 22, six female scientists and twelve male scientists improved their education as either post-doctoral scientists (4) or visiting scientists (14). Their research activities were in the disciplines of plant breeding, food quality/utilization, economics, plant pathology, and *Striga* physiology. These scientists came to the United States as post-doctoral scientists or visiting scientists from Argentina, Botswana, Brazil, El Salvador, France, the Gambia, Hungary, Mali, Nicaragua, Niger, and the United States.

Networking

The Sorghum/Millet CRSP Global Plan for Collaborative Research includes workshops and other networking activities such as newsletters, publications, the exchange of scientists, and the 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 (ROCAFREMI, ROCARS, ASARECA, SADC/SMINET, SADC/SMIP 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), promote germplasm and information exchange, and facilitate impact evaluation of new technologies.

- Develops regional research network, short-term and degree training plans for sorghum and pearl millet scientists.

Over the years, established networking activities have been maintained with ICRISAT in India, Mali, Niger, Central America and Zimbabwe; SAFGRAD, WCASRN, WCAMRN, 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 the ICRISAT programs in East, Southern, and West Africa, with WCASRN and WCAMRN in West/Central Africa and with SMIP/SMINET in Southern Africa. Sudanese collaborators have provided leadership to the Pan African *Striga* Control Network. INTSORMIL collaboration with ROCAFREMI in West Africa has much potential in allowing INTSORMIL utilization scientists to collaborate regionally. ROCAFREMI is a good mechanism for promoting millet processing at a higher level than has been seen before in West Africa. During the last four years, INTSORMIL, the Bean/Cowpea CRSP and World Vision International have been working with NARS researchers and farmers in five countries under the West Africa Natural Resource Management Project, creating and using a technology-transfer network in West Africa. INTSORMIL will continue to promote free exchange of germplasm, technical information, improved technology, and research techniques.

Regional Activities and Benefits

West Africa

This was certainly a year of transition for the West Africa regional activities with the passing away of John Axtell. Several accomplishments for the year indicate continued emphasis of INTSORMIL on a regional approach to strengthen research capabilities and use research to fight hunger and poverty in West Africa.

A meeting of INTSORMIL investigators was held in Niamey, Niger in March 2000 to review projects, discuss future plans and strategies, and develop new collaborative research in northeastern Nigeria. These new collaborative research activities, at the Lake Chad Research Institute and University of Maiduguri in Nigeria, will focus only on millet and will add to the hybrid millet breeding and millet utilization work with ICRISAT (Dr. Gupta) at the university there. Another meeting was held in the Spring of 2001 to bring in additional regional investigators and complete strategic planning for the regional thrust.

In the Niger hybrid sorghum project, research on development of new improved hybrids is coming to fruition with a number of improved hybrids for early maturity and good grain quality. Seed production, a hurdle to overcome in making hybrids a realization, is progressing with the organization of a seed association. Possible collaborations with other projects (e.g., the Millet and Sorghum Initiative funded by IFAD and others) will help this effort.

The Niger utilization project on processing of high quality flours and agglomerated products (mainly couscous) has progressed with one-half of the market study completed. Results are very positive in terms of responses to commercial potential of NAD-1 hybrid sorghum couscous. Public exhibitions also took place in 2000 and 2001 that have raised public awareness of the sorghum/millet processing unit, breeding of hybrid sorghum, and seed production activities. NGO's were visited to begin to try to get financing for commercial units. The next step is clearly to initiate commercial processing of couscous and flours, and this may require some additional financing. Carl Nelson assisted in the design of the market study and Jupiter Ndjeunga traveled to Niger to assist with design and implementation.

Projects on entomology, agronomy, and pathology are all active in Niger and have made significant contributions to developing varieties of sorghum resistant to midge, developing tied-ridge technology appropriate to Nigerien cropping systems, and improving our knowledge of the biology of sorghum nematodes. Scientists in all disciplines in Niger, Nigeria and Burkina Faso are in need of U.S. collaborators, particularly in entomology and plant pathology. Steve Mason has agreed to assist Seyni Serifi in agronomic research in Niger. Dr. Mason also has two students at Nebraska from the region (Niger and Burkina Faso). Researchers in economics continue to be active. Tahirou Abdoulaye, a graduate student at Purdue, has done significant field research in Niger, primarily on fertilizer adoption. INTSORMIL began collaborative research with plant pathologists, agronomists, and plant breeders in Burkina Faso.

The successful use of N'Tenimissa flour by a private bakery in Mali to make a cookie using some sorghum flour was important and demonstrated that new improved food quality cultivars can stimulate new commercialization of sorghum based products. Most recently, 100% sorghum biscuits are being made by IER and various individuals in Bamako. Marketing of the 100% sorghum biscuits is being done by ROCARS to popularize the product in a number of countries in West and Central Africa.

Collaborative research was initiated in Ghana and Senegal, and a MOU was approved with ISRA in Senegal. There was much interest and desire in both countries to expand the initial collaboration to additional scientists and research areas, but it appears that funding will be difficult to obtain for any major program growth in the near future. Several other countries expressed intense interest in April at the ROCARS meeting in Mali on how they could get involved in INTSORMIL. The expansion into new countries is a good move, but we must be careful to not create unrealistic expectations in the four new countries in West Africa in which INTSORMIL is beginning to devote more resources, or those and other countries may perceive INTSORMIL's PIs as not being able to deliver.

Horn of Africa

In Year 22, under the auspices of IGAD with funds provided by USAID/REDSO/EA, a major study assessing the state of dryland research in the Horn of Africa region was conducted under the leadership of Dr. John Sanders and in cooperation with a number of agricultural scientists from the Horn of Africa.

The survey provides extensive documentation regarding dryland agriculture in the region, technologies available, and research gaps that can be addressed through future research. A stakeholders' workshop is planned for later in the year to discuss the results of this study and to develop a dryland research agenda for the Horn of Africa.

Dr. John Sanders and his graduate student, Negga Wubneh, also completed a field study on the assessment of the impact of *Striga*-resistant sorghum varieties and associated technologies recommended for use in Ethiopia by INTSORMIL. These technologies include *Striga*-resistant varieties, nitrogen fertilization, and tied-ridging as a moisture conservation measure. Analysis and publication of this field study are expected to be completed in early 2002.

On-going collaborative research has progressed in each of the countries, namely Ethiopia, Eritrea, Kenya and Uganda; the results from each of these studies is documented in this report. INTSORMIL investigators in each country have taken keen interest in collaborating with U.S. investigators where partnerships have been developed. Because of expanded collaborative involvement in several countries, more U.S. investigators are needed to provide collaborative linkages with scientists in the region. New investigators joining INTSORMIL are expected to take advantage of the opportunities for collaboration in the Horn of Africa, where host country scientists and programs continue to appreciate and welcome technical support provided by collaborating scientists in the United States.

Southern Africa

Most activities were carried out as planned. Some logistical constraints hindered the research effort. However, research is on-going and, depending on the program, continues to make good progress toward objectives and has produced results that are important to increasing the production and quality of end-products of sorghum and pearl millet in Southern Africa.

Hybrid parents have been bred for sorghum and are nearing completion for pearl millet. A large amount of sorghum breeding material and varieties in use have been characterized for resistance to major diseases and sugarcane aphid. Multi-location testing of sets of such lines provides strategic ecogeographic information on distribution and severity of diseases. Factors influencing the incidence and control of sorghum ergot are now better understood, leading to better control of the disease, especially in hybrid production fields. Food quality research can lead to increased use of sorghum in various products. Linking variety qualities to specific end uses is proving to be very important.

Collaboration continues but is in transition due to retirements of INTSORMIL principal investigators. Active collaboration exists in sorghum breeding, plant pathology, grain quality, and marketing. Regional pearl millet breeders and entomologists continue interaction with INTSORMIL at a reduced level due to retirements. Efforts are on-going to continually refocus activity for increased relevance and generation of useful technology. Collaboration can be improved and increased in all research areas. Additional collaboration is needed in all disciplines for all research objectives. Unfortunately, there are more collaborators and opportunities in Southern Africa than there are INTSORMIL investigators in the United States.

Central America

The Central America program continues to evolve from a program focused on Honduras to a more regional program with increased activity in El Salvador and Nicaragua. Concurrent with this evolution has been increased collaborative research in plant pathology and agronomy. The research activities planned at the INTSORMIL Research Planning Meeting in October, 2000 were successfully implemented. After completion of the 2001 year research, a conference will be held to report research results and plan collaborative research activities The major programming challenge for 2002-2006 is to match activities to the available budget, and to develop more interdisciplinary activities. Graduate education of scientists in national programs is needed, but identification of candidates who are proficient in English with firm commitments to work in national programs is difficult, and funding is limited. On the whole, given the short time in the present collaborative model in Central America, the program is functioning well due to the commitment of scientists in the region.

Regional Benefits by Technical Thrust

INTSORMIL provides a wide range of documented benefits to collaborating countries, U.S. agriculture, and the broader scientific community. Many of these benefits have reached fruition with greater economic benefits to producers and consumers, improved sorghum and millet research programs, and improvement of the environment. Others are at intermediate stages ("in the pipeline") that do not allow quantitative measurement of the benefits at present, but do merit identification of potential benefits in the future. The collaborative nature of INTSORMIL programs has built positive long-term relationships between scientists, citizens and governments of collaborating countries and the United States. This has enhanced university educational programs and promoted understanding of different cultures enriching the lives of those involved, and hopefully making a small contribution to world peace, in addition to improving sustainable sorghum and pearl millet production in developing countries and in the United States.

Germplasm Enhancement and Conservation

Breeding sorghum varieties and hybrids for use in developing countries and the United States requires proper recognition of the major constraints limiting production, knowledge of germplasm, and an appropriate physical environment for evaluation and testing. Successful breeding efforts also require knowledge of mode of inheritance and association of traits that contribute to productivity as well as tolerance to biotic and abiotic stresses. Germplasm exchange, movement of seeds in both directions between the United States and collaborating countries, involves populations, cultivars, and breeding lines which carry resistance to insects, diseases, the parasitic weed, *Striga*, drought, and which are tolerant to edaphic stresses, one of which is soil acidity. Research and germplasm development activities in INTSORMIL attempt to address these essential requirements.

INTSORMIL/Purdue project (PRF-207) addresses major biotic and abiotic constraints (drought, cold, grain mold, and other diseases) that limit productivity of sorghum in many areas of the world. Over the years significant progress has been made in some of these areas. Superior raw germplasm have been identified, mode of inheritance established, chemical and morphological traits that contribute to productivity as well as to tolerance to these stresses have been identified. Selected gene sources have been placed in improved germplasm background, some of which have already been widely distributed. Training of NARS scientists is an important component of our research and development effort.

INTSORMIL plant breeders also develop elite materials with high yield potential which can be used as cultivars *per se* or used as parents in breeding programs. Specific germplasm releases (including breeding lines) for collaborating country use include the following.

- Improved yield (for all collaborating countries)
- Improved drought tolerance (Africa and drier areas of Latin America)
- Acid soil tolerance
- *Striga* resistance (West, Eastern Africa, and Southern Africa)
- Midge and greenbug resistance (Latin America)
- Downy mildew resistance (Latin America and Botswana)
- Anthracnose resistance (Latin America and Mali)
- Charcoal rot and lodging resistance (Africa and drier areas of Latin America)
- Head smut and virus resistance (Latin America)
- Foliar disease resistance (for all collaborating countries)
- Improved grain quality characteristics for food and industrial uses (for all collaborating countries)

The commitment of INTSORMIL to integrated pest management of insect pests and pathogens has produced new lines of sorghum useful to commercial breeders and seed companies for both marketing hybrids and developing more advanced hybrids. Germplasm obtained and evaluated for resistance to economically important insect pests was used to combine insect resistance with other favorable plant traits. Germplasm was identified for advanced testing with resistance to selected insects and diseases, and will contribute to production of widely adapted, high yielding hybrids. Techniques of molecular biology are being used to help understand the inheritance of resistance to greenbug. Results from molecular mapping of sorghum are being used in marker-assisted selection studies for greenbug resistance and post-flowering drought tolerance.

INTSORMIL has been working since the mid-1980's to help Niger develop a hybrid seed industry. Beginning with initial experiments with hybrid sorghum in the 1980s, INTSORMIL scientists of Niger and the United States have collaboratively developed a hybrid sorghum, NAD-1, which is well adapted to conditions in Niger, yields higher than most local varieties and has acceptable qualities for consumers. Following a hybrid sorghum and millet workshop held by INRAN, INTSORMIL and ICRISAT in Niamey in 1998, our private-sector partners in Niger, with the cooperation and support of the public sector, have made significant progress in the production and sale of NAD-1 hybrid sorghum seed. INRAN and the Government of Niger are supportive of this private seed sector activity. NAD-1 will be the first hybrid seed produced and marketed by this company. Second, several hybrid sorghum seed producers in Niger have formed a seed producers association. This association recognizes INRAN as an honorary member, but is intent on keeping the seed producers' association outside of the formal structure of the government. INTSORMIL thinks this is an encouraging development which should be nurtured. Third, the demand for hybrid seed far exceeds the supply even though the seed is sold at approximately eight times the price of grain. The important distinction between seed and grain is now recognized in Niger. We estimate that 60 tons of hybrid seed will be produced this year in Niger. A great deal of this seed production will be on small farms. During the past year, Nigerien and American food scientists in the INTSORMIL program have collaborated on pilot-plant production of high-quality flour, couscous, and degué (a breakfast food) from NAD-1 hybrid sorghum. INTSORMIL agricultural economists are surveying consumer preferences to provide useful information for marketing of these improved sorghum products.

Several U.S. seed companies are now producing seed of brown midrib sorghum sudangrass commercially. The response of livestock producers has been excellent due to improved digestibility and significantly improved palatability. Dairy farmers are the first to see the benefits of the improved nutritional quality in increased milk production. There are approximately five million acres of sorghum sudangrass in the United States at the present time, compared with nine million acres of hybrid sorghum for grain production. The potential of brown midrib sorghum sudangrass in West Africa is being explored through collaborative INTSORMIL research of American scientists and Nigerien scientists led by Dr. Issoufou Kapran in Niger. The value of forage in West Africa is high and there is a chronic shortage of high-quality forage, which we believe can be partially alleviated by brown midrib sorghum sudangrass hybrids. To date, there has been extensive cultivation of brown midrib sorghum hybrids in Pakistan and in some Asian countries. The potential value in India has been recognized, since India is now the largest milk producer in the world and they are heavily investing in research on brown midrib forage cereals. As we enter the next decade of the "meat revolution" forage crops will increase in importance.

INTSORMIL/Purdue University have developed a rapid screening technique for breeders to assess the new high digestibility trait recently discovered in sorghum germplasm. The new rapid screening technique, which measures disappearance of ᾳ-kafirin in sorghum grain has been developed by INTSORMIL P.I., Bruce Hamaker and his Nigerien Post Doctorate Fellow from Niger, Dr. Adam Aboubacar . The test is rapid and readily distinguishes between normal sorghum and the highly digestible sorghum cultivars. A graduate student, Mr. Lex Nduulu from Kenya has tested this technique across several environments and found that it is accurate and yet simple enough to be applied to large populations of breeding materials. He is determining the mechanism of inheritance of the high digestibility trait.

INTSORMIL collaborative research is proving useful to sorghum breeders worldwide. The use of DNA-based markers for genetic analysis and manipulation of important agronomic traits is becoming increasingly useful in plant breeding. In a recent study, 190 sorghum accessions from the five major cultivated races, namely *bicolor, guinea, caudatum, kafir, and durra,* were sampled from the world collection maintained by ICRISAT. Genetic variation was detected using RAPD primers. Only 13% of the total genetic variation was attributable to divergence across regions, but South African germplasm exhibited the least amount of genetic diversity, while the genetic diversity within the West African, Central African, East African and Middle Eastern regions was high among the 190 samples from the world collection. This research showed that molecular markers can be used to help identify suitable germplasm for introgression into breeding stocks. Selecting the most divergent accessions for introgression may increase the probability of extracting suitable inbred lines to improve the yields of varieties and hybrids.

Producing improved seed that seed companies and farmers can use, INTSORMIL researchers in developing countries and the United States have collaborated to develop improved, high yielding varieties and hybrids. Progeny were identified that combine several needed favorable traits into a single genotype. Advanced selections are being evaluated using on-farm trials to measure performance. As research continues to generate new technology, the importance of testing on-farm, and soliciting producer input on research activities will increase. Technology–in this case, improved germplasm–developed by INTSORMIL has been adopted by private industry and used in hybrid production and breeding programs. Impact assessment studies have consistently shown a high rate of return on investment from research conducted by this project.

In pearl millet breeding, in the first year of the project for the cytoplasm/genotype crosses INTSORMIL was able to obtain consistent results from Niger, India and the USA. The grain yields of the population hybrids compared to their land race parents were similar to what was expected. However, the lower-than-expected yields due to non-adaptability of the population hybrids in the locations tested was unexpected. In the future, the collaborative research of INTSORMIL millet breeders will need to produce population hybrids among locally adapted genotypes. The principal investigator doing pearl millet breeding in Georgia has decided to maximize impact by having visiting scientists spend time with him during the pollinating season. The visit from Moussa Sanogo was beneficial for him and he will get a publication in the International Sorghum and Millet Newsletter from the visit.

Good progress was made in achieving the objectives of INTSORMIL's project for germplasm enhancement for resistance to pathogens and drought and increased genetic diversity (TAM-222). The Mali Collection effort was essentially completed and some very unique elite-appearing exotic cultivars were identified. Broad-based germplasm development and distribution continued and showed promise in Mali, Nicaragua, El Salvador, Zambia, and South Africa. A good portion of the PI's time is devoted to evaluating, identifying, and deciding which germplasm lines and parental lines to release and how to release various materials. A larger number of releases is anticipated this next year.

INTSORMIL's project for germplasm enhancement for resistance to insects and improved efficiency for sustainable agricultural systems (TAM-223) progressed in all research areas. Germplasm was obtained and evaluated for resistance to economically important insect pests. Selections were made to combine insect resistance with other favorable plant traits. Germplasm was identified for advanced testing with resistance to selected insects and diseases that will contribute to production of widely adapted, high yielding hybrids. Results from molecular mapping are currently used in marker-assisted selection studies for greenbug resistance and post-flowering drought tolerance. Collaboration with LDC scientists resulted in progress to develop improved, high-yielding varieties or hybrids. Progeny were identified that combine several favorable traits into a single genotype. Advanced selections are being evaluated by on-farm trials to measure performance. As research continues to generate new technology, the importance of testing on-farm and soliciting producer input on research activities is increasing.

During the life of TAM-223, significant research objective progress has been achieved. Technology (germplasm) developed by this project has been adopted by private industry and used in hybrid production or breeding programs. Collaboration has recently been established with research programs in Nicaragua, El Salvador, and Southern Africa (South Africa, Botswana, Zambia, and Mozambique). Impact assessment studies have consistently shown a high rate of return on investment from research conducted by this project.

Sustainable Production Systems

In West Africa, INTSORMIL's main collaborative agronomy research activities have been focused in Mali and Niger. However, a memorandum of understanding was signed in 1999 with IN.E.R.A., the NARS of Burkina Faso, and collaborative research was initiated in Burkina Faso. INTSORMIL also participates in the West and Central African Sorghum and Millet Research Networks. In research conducted during the past four years, it was determined that high-yielding grain sorghum genotypes that are tall or have high vertical leaf area distribution can be more competitive with weeds and, therefore, be a useful component of integrated weed management programs. Studies on management of late-maturing Maiwa pearl millet in southern Niger were initiated. Because this variety of pearl millet tillers profusely, it provides a unique opportunity to integrate grain production for human consumption and forage production

to support livestock. Initial results that tillers can be harvested 65 to 85 days after planting for use as livestock feed without reducing grain or stover yield point to development of a more economically rewarding cropping system for millet farmers in the Sahel.

This project has been extremely productive in graduate education of West African collaborating scientists; agronomic research which has led to publication in scientific journals, the publication of extension bulletins, and the transfer of improved practices to pearl millet producers; and strengthening the activities of the West and Central Africa Pearl Millet Research Network. In the USA, the project has documented the potential for pearl millet as a new grain crop in the Great Plains, and developed production practice recommendations for planting date, row spacing, and nitrogen fertilizer application. During the past year, research activities have expanded from West Africa to Central America. The pending merger of the West and Central Africa Pearl Millet and Grain Sorghum Research Networks has potential to enhance project activities. Nebraska research on pearl millet is severely constrained by the lack of a pearl millet breeding program in the Great Plains, and the lack of private sector investment in developing pearl millet as an alternate grain crop.

INTSORMIL's project on nutrient efficiency in sorghum and pearl millet completed activities in all countries as planned. On-farm trials successfully demonstrated the value of using new hybrids, inorganic fertilizer and tied ridges to conserve moisture which is now being adopted in certain regions of Niger. Contacts were made between NARS scientists in Ghana, Mali and Niger and WVI personnel as expedited by the UNL-214 PI. Collaboration between and among these individuals should result in greater efficiency for extending new technology. The underlying physiological mechanism for NUE was determined to be a key enzyme in the photosynthesis pathway. This discovery was published in a major journal.

In the project, Economic and Sustainability Evaluation of New Technologies in Sorghum and Millet Production in INTSORMIL Priority Countries (PRF-205), the Senegal and Mali reports for the three-country study of the potential impacts from new technologies and supporting policies were completed. The final report on Niger is well advanced and will be completed in early 2002. This Niger project has been partially supported by ICRISAT. The farmer decision-making model was the same across these three countries and the technologies similar so the comparison and contrast will be instructive. This field research is on schedule with the synthesis of the three country results due out in 2002.

The two-volume, six-country study of the potential of new dryland technologies in the Horn has been published and distributed. A workshop on these results will be held in the fall of 2001. Finishing this report was delayed as key personnel were not allowed into the Sudan and the time frame given by IGAD turned out to be too short for the desired scope of the report.

The fieldwork for the study on the diffusion of *Striga*-resistant sorghum cultivars and associated technologies was completed in Tigray, Ethiopia in this fiscal year and the report on this will be available in 2002. The perennial problem of this fieldwork on diffusion and impact analysis is transportation. The agricultural service of Tigray National Regional State contributed transport vehicles in support of this activity..

Sustainable Plant Protection Systems

INTSORMIL's approach to developing sustainable plant protection systems is integrated pest management (IPM). Two key elements of IPM for sorghum and millet which are central to INTSORMIL plant protection research are genetic resistance of sorghum and millet to insect pests, pathogens, and the parasitic weed, *Striga*, and practices to control insects and pathogens with minimal use of chemical pesticides. INTSORMIL entomologists and plant pathologists work closely with plant breeders, agronomists and food scientists to develop more effective means to manage pests of sorghum and millet in order to provide higher yields of higher quality grain per unit area cultivated. Intensification of agricultural production, which can help remove pressure on fragile ecosystems, depends on many factors; sustainable, plant protection is essential to increase production of food and feed from sorghum and millet in economically and ecologically sustainable ways. In crop protection, a wide range of sources of resistance for insects, diseases, and *Striga* have been identified and crossed with locally adapted germplasm. This process has been improved immensely by INTSORMIL collaborators developing effective resistance screening methods for sorghum head bug, sorghum long smut, grain mold, leaf diseases and *Striga*.

Witchweeds (*Striga* spp.) are obligate parasitic weeds of significant economic importance. Control methods available to date have been costly and beyond the means of farmers in developing countries. While combining several control measures may be necessary to eradicate *Striga*, crop losses to *Striga* can be effectively minimized through host-plant resistance. In the INTSORMIL project, *Striga* Biotechnology Development and Technology Transfer (PRF-213), the goal has been to exploit the unique life cycle and parasitic traits of *Striga* to develop sorghum lines that are resistant to *Striga* because of disrupted interaction between the parasite and the host. INTSORMIL's *Striga* research program is progressing well. Investigators in Project PRF-213 have made significant advances in our pursuit of understanding the biology of host parasite interaction in *Striga* parasitism. The collaborative research team has exploited the biological relationship between *Striga* and its hosts in identifying and characterizing mechanisms of *Striga* resistance in sorghum. The work is exemplary and provides parallel for similar gains in maize and other crops. Collaborative linkages with ICRISAT and several NARS

have been developed and strengthened. Training of NARS scientists is an important component of INTSORMIL's *Striga* research and development effort. Seed supply is likely to be a bottleneck in efforts to promote an expanded cultivation of these varieties. However, INTSORMIL received additional support in Year 22 to cooperate with the NARS of Ethiopia to organize and deliver a sorghum production technology package in *Striga*-affected areas in Ethiopia. This technology project will include multiplication of well-adapted, *Striga*-resistant sorghum, acquisition and packaging of fertilizer, production of plows to make tied ridges, training of trainers, and, finally delivery of the seed, fertilizer, plows and training to farmers.

INTSORMIL's project on agroecology and biotechnology of fungal pathogens of sorghum and millet from the Greater Horn of Africa (KSU-210) has changed its geographic focus to Central America. A short course was conducted at Kansas State for two scientist collaborators, Ings. Reina Guzman and Sergio Pichardo. The laboratories in the host countries are being updated very slowly and much improvement remains as El Salvador and Nicaragua were involved in political strife for nearly twenty years. The objectives of the collaborative project are on schedule as were initially planned.

Sorghum and maize are important grain crops for human consumption and animal feed in developing countries in Central America. The crops are damaged each year by soil inhabiting insects, stem borers, caterpillar defoliators, and panicle feeding insects that contribute to reduced yields of both crops on farms in this region. The complex of defoliators and sorghum midge are considered to be the most damaging to these crops in Honduras and Nicaragua, and annually cause extreme damage to the crops. Research in Honduras in 2000 resulted in partial explanation for differences in occurrence of the principal insect pest constraints to sorghum and maize production in contrasted hillside and coastal plain production systems. The limited success was due to the harsh environmental conditions experienced in the experimental areas. The damage to both crops and ultimately the complete sorghum crop destruction limited or prevented yield measurements for the experimental treatments. Nevertheless, the information obtained in 2000 on the influence of soil moisture on termination of diapause (dormant stage of pupae) and survivorship of this immature stage will benefit the development of integrated insect pest management programs for this region. Studies in the USA to better define the economic threshold of fall armyworm and sorghum midge on sorghum will assist farmers in decision-making regarding the application of insecticides to control these pests.

In INTSORMIL's project on agroecology and biotechnology of stalk rot pathogens of sorghum and millet (KSU-210A), collaborating investigators have collected important new populations of *Fusarium*, and new species have been identified. Some of these species are now being used in field tests on sorghum to determine their relative pathogenicity, primarily for stalk rot. Plans for cooperative work on grain mold of both millet and sorghum are being developed. Molecular diagnostic tools have been developed and should speed diagnoses. Studies of mycotoxin production at a relatively gross level have been completed, but details of the genetics, physiology and environmental parameters that control their synthesis under field conditions need further attention. Present results indicate that species identification may be critical in estimating the risks posed by mycotoxins, and that many of the *Fusarium* species common on sorghum do not make high levels of many of the common mycotoxins. The development of the Scientific Writing and *Fusarium* Laboratory workshops were not a part of the original planned activities, but have been very successful outreach efforts that will be continued. The Scientific Writing and *Fusarium* Laboratory workshops serve as interdisciplinary venues for scientists in developed and developing countries that work on various crops to exchange information and to interact with one another in an informal setting.

Investigators of project KSU-210A have also been carrying out systematic strain collection and strain identification; their development of AFLPs as a means to distinguish species should accelerate this process. This research team plans to purchase equipment to automate much of this process during the coming year. The Principal Investigator will be on sabbatical from January – August 2002, and work while he is gone will focus on the continuing characterization of existing collections. He will attempt to add larger collections from pearl millet from West Africa during September 2001, to augment the rather meager existing collections in this area and to provide enough material for mycotoxin analyses of grain-mold contaminated pearl millet.

Toxicology work now requires a collaborator who can test the effects of toxins in commercial animal feeds and who can model their effects in laboratory systems, using human and animal cell lines as models. Screening of grain for these toxins needs to be done to determine relative levels of these toxins in animal and human food supplies.

The INTSORMIL project on insect pest management strategies for sustainable sorghum production (TAM-225) was completed, and two graduate students who had begun their graduate studies with the Principal Investigator continue to be supported after his retirement and until they graduate. Both are doing research on aspects of the biology of greenbug, an economically important insect pest of sorghum. One of the students is studying genetic diversity in natural populations of greenbug for her dissertation research. She has been conducting phylogenetic analyses of three mitochondrial (mtDNA) gene fragments to determine evolutionary relationships among biotypes and greenbug individuals collected from the field. Other techniques were used to assess genetic diversity in natural populations of greenbugs from the field. This study helps confirm the belief that greenbug biotypes have not shared maternal lineage within the past 0.3-0.6 million years. The other graduate stu-

dent who is completing his studies with support from this project is studying, for his dissertation research, evolution of greenbug (Homoptera: Aphididae) biotype fitness and virulence on sorghum and wild grasses. He has been conducting research with four genotypes of sorghum and nine greenbug biotypes to determine fitness of adult females and fitness of colonies, based on intrinsic rates of increase calculated from nymphs and colony growth rates. In addition, he is determining virulence of greenbug biotypes on different genotypes of sorghum and some grass species. He is determining effects of temperature and humidity on virulence of selected greenbug biotypes and is using cDNA subtraction to determine genetic difference in sorghum genotypes that correlate with virulence and fitness differences in greenbug biotypes.

Crop Utilization and Marketing

This was a sad year with the death of Dr. John Axtell. Apart from being a close collaborator on INTSORMIL's sorghum digestibility work, John was a friend and leader in sorghum research. It is the hope of the Principal Investigator of INTSORMIL's project on chemical and physical aspects of food and nutritional quality of sorghum and millet (PRF-213) that this food-science research team will be able to continue and complete the work the team had ongoing on improving nutritional quality of sorghum grain. Although in many respects this was a year of transition including students graduating and new ones beginning projects, this food science research team made progress in a few important areas. In nutritional quality research, notable progress was made using John Axtell's recent crosses of high protein digestibility material with the very hard "rice-type" sorghums. Some progeny were identified at the F_4, containing kernels with vitreous endosperm which appears nearly normal and contains the abnormally-shaped protein bodies typical of the high digestibility mutant. This was good news, as it shows that this combination is possible. In other related work done with Murty and Chandrasbekar in India, early data look similarly good with the possibility for a stable, improved, grain with highly digestible protein. However, it is still too early to say this definitively. In their research on starch digestibility, they showed that the high protein digestibility mutant gives a higher rate of starch digestion in a cooked porridge system. If this bears out *in vivo*, improved weaning foods and other foods with increased availability of energy could be developed from grain that has higher levels of protein digestibility.

In Niger, the couscous/high quality flour project continues to progress, though always at a seemingly slower pace than is initially planned. The first phase of the market study has been completed, that being an in-home consumer test. The results were very positive with respondents rating the sorghum NAD-1 couscous highly in all sensory categories and overwhelmingly indicating that it should be commercialized. The actual market test in Niamey stores and public market is taking place in the summer of 2001. Two expositions on the processed sorghum products and the hybrids held in the Fall 2000 went very well. Adam Aboubacar traveled to Niamey in August 2000 and assisted in these activities. There continues to be a high level of enthusiasm for this project at INRAN which is now shared by many government officials and potential entrepreneurs. The barrier to get over is initiating actual commercial units. INTSORMIL scientists have talked with various NGOs in Niamey (Africare, World Vision, AfriqueVert) as well as some individuals. It seems like a critical time to try to make some commercialization effort a realization. In March 2001, INTSORMIL scientists met with a local entrepreneur who is a member of the processor association set up two years ago by the INRAN food processing group. She has proposed that she have some access to the unit and sell product in Niamey to begin to establish a market. Perhaps this will be the way to at least get commercialization started in a small way. The two Nigerian scientists who came to the meeting in Niamey in March from Maiduguri were also interested in using these technologies in Northern Nigeria for millet hybrid products.

In Ethiopia, INTSORMIL is still moving quite slowly in the food utilization area. Plans to buy an entrepreneurial-scale decorticator and mill for the Nazret station were set back due to the Dakar-based company going out of business. Another company (European-based with a Dakar office) that can fill this order has been identified, and it is hoped that those units will be put in place in the coming fiscal year. Regarding Kenya, Betty Bugusu continues in her doctoral studies at Purdue. She is making very good progress and is an excellent student.

With INTSORMIL's project on food and nutritional quality of sorghum and millet (TAM-226) there is also progress on several fronts. New markets for value-enhanced white food sorghums are being promoted by the U.S. Grains Council from INTSORMIL's research on food sorghum processing and prototype products. In Japan, value-enhanced white food sorghums are processed into four or more commercial snack foods. Initial sales are promising. Sorghum flour was demonstrated effective in nearly 20 traditional Japanese foods by Japanese chefs and food processors.

Several mills are producing sorghum flour for niche markets. In Central America, white sorghums are used in cookies and other products as a substitute for wheat or maize. Several parental sorghum lines released from INTSORMIL are used in commercial hybrids grown in Mexico and the United States. ATx 635 hybrids have outstanding milling properties.

The antioxidant level in certain bran fractions of special sorghums is higher than that of blueberries, and special sorghums with high levels of phenols and antioxidants produce excellent chips and baked products. Antifungal proteins appear related to grain mold resistance in sorghum. A molecular linkage map for sorghum kernel characteristics, milling properties, and mold resistance is nearing completion.

The activities of TAM-226 in Honduras, El Salvador and Southern Africa are top priority. The new emphasis on food science and technology at EAP in Honduras was encouraging, however, they currently seem disinterested in meaningful collaboration. The opportunity to develop a more comprehensive program in El Salvador and Honduras is challenging.

In Africa, the inability to produce large quantities of N'Tenimissa of good pure quality in Mali followed by meaningful demonstrations of its worth to industry has been disappointing. The overall morale of IER personnel has, however, improved, and production of a concentrated sorghum-based drink and 100% sorghum cookies are encouraging developments. Implementing value-added processing may still occur. Research activities at the University of Pretoria in South Africa continue. The chance to interact with a good cadre of Southern and East African students at University of Pretoria is a unique opportunity. The departure of Dr. Trust Beta from the University of Zimbabwe is a setback.

The uncertainty of funding from year to year inhibits commitments to graduate training. Inflation has eroded away much of our graduate training capabilities. The continued success of our projects is due to our access to Non-INTSORMIL supported projects in breeding (W.L. *Bill* Rooney) and grain mold research (R.D. Waniska). Our ability to attract additional financial support for the work has allowed continued productivity. The funds from INTSORMIL have relatively little buying power since we have about the same number of total dollars we had 20 years ago.

Millet research has been minimized as funds from INTSORMIL decrease in actual buying power. Millet is not a crop in Texas and leveraged funds of INTSORMIL scientists in Texas from other sources are all for sorghum research. Overall, INTSORMIL scientists are quite productive, but cannot do everything that is required because of lack of funds.

Future Directions

Based on its achievements, the INTSORMIL team is well positioned to contribute even more effectively to ending hunger and raise incomes. With its 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 22 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 keys 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 have a sustainable and global impact.

In the past, INTSORMIL focused a major part of its resources on graduate student training and generating research particularly useful within the scientific community. The INTSORMIL agenda for the future continues to include graduate student training and generation of scientific knowledge and information to scientists, but will be more focused and directed toward users of the technology generated by INTSORMIL research. Future strategies of INTSORMIL 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 for 2001-2006 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.

INTSORMIL Global Plan

Education Strategies

Programs

- Post-secondary Education
- Short-term training
- Post-doctoral assignments
- Seminars, Workshops, Conferences

Outcomes

- Institutional Strengthening
- Collaborative Research Networks
- Technology Transfer and Dissemination Infrastructure
- National, Regional and Global Communication

Peer
← Collaboration →

Research Strategies to Resolve Constraints

Main Objectives

- Promote economic growth
- Improve nutrition
- Increase yield
- Improve institutional capability

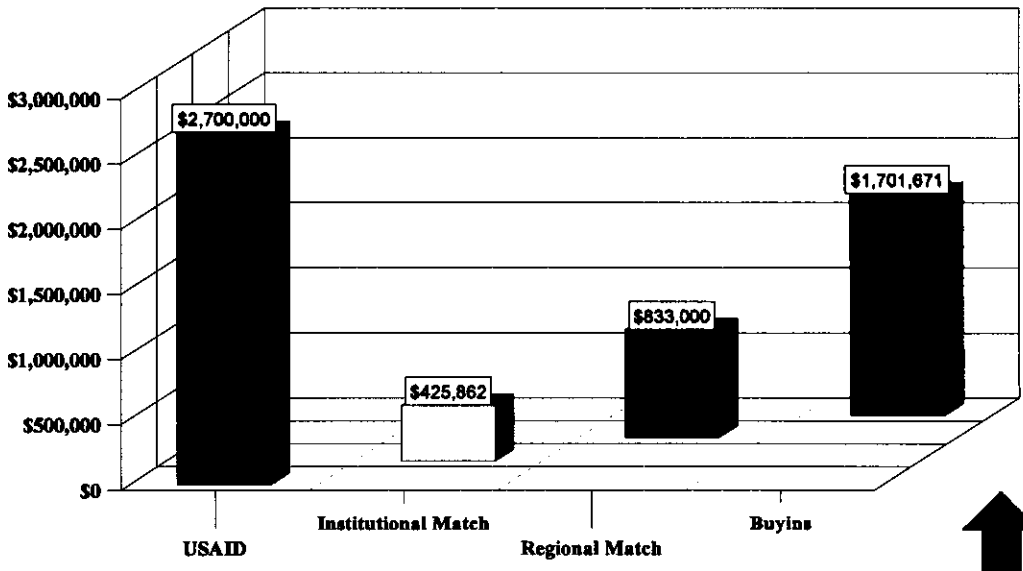
Outcomes

- Development and Release of Enhanced Germplasm
- Development and Improvement of Sustainable Production Systems
- Development of Economic Models for Prioritization of Research and Farm-level Industry Evaluation.

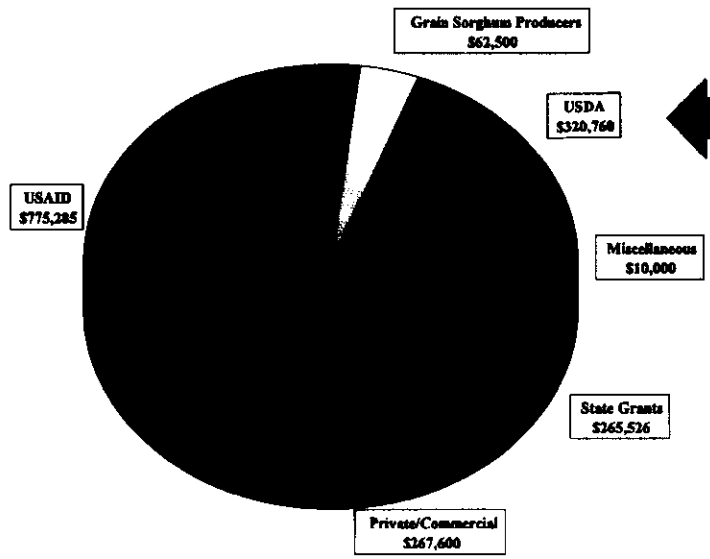
Networking
Communication
TechnologyTransfer

Farmers

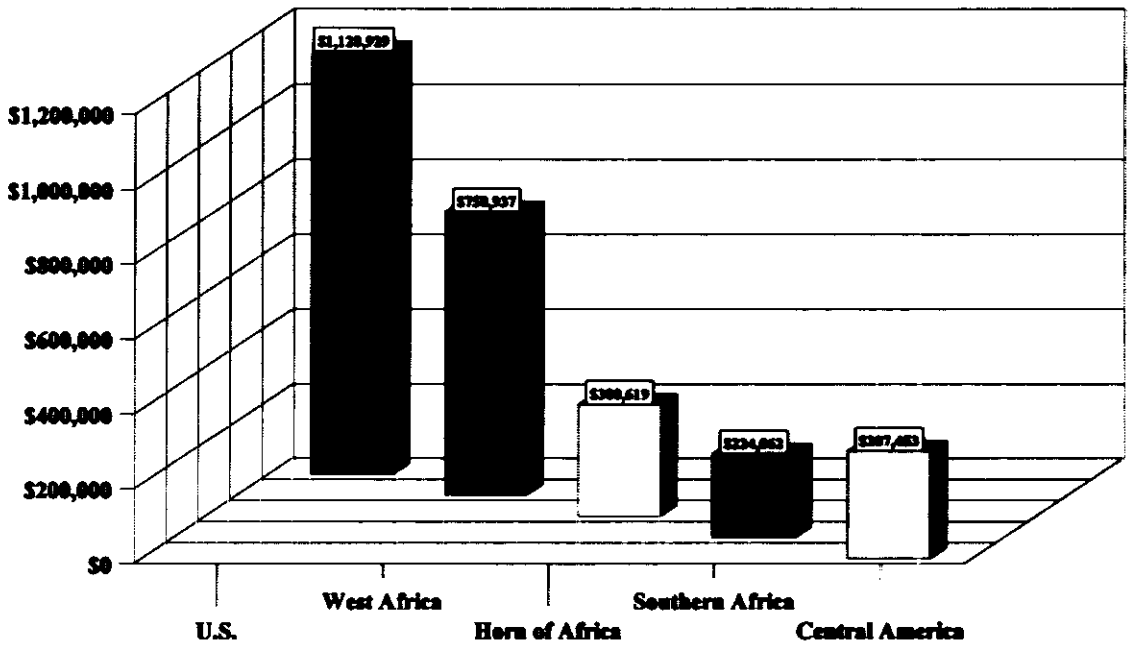
FY 2001 INTSORMIL Source of Funding
July 1, 2000 - June 30, 2001
Total Year 22 - $ 5,660,533



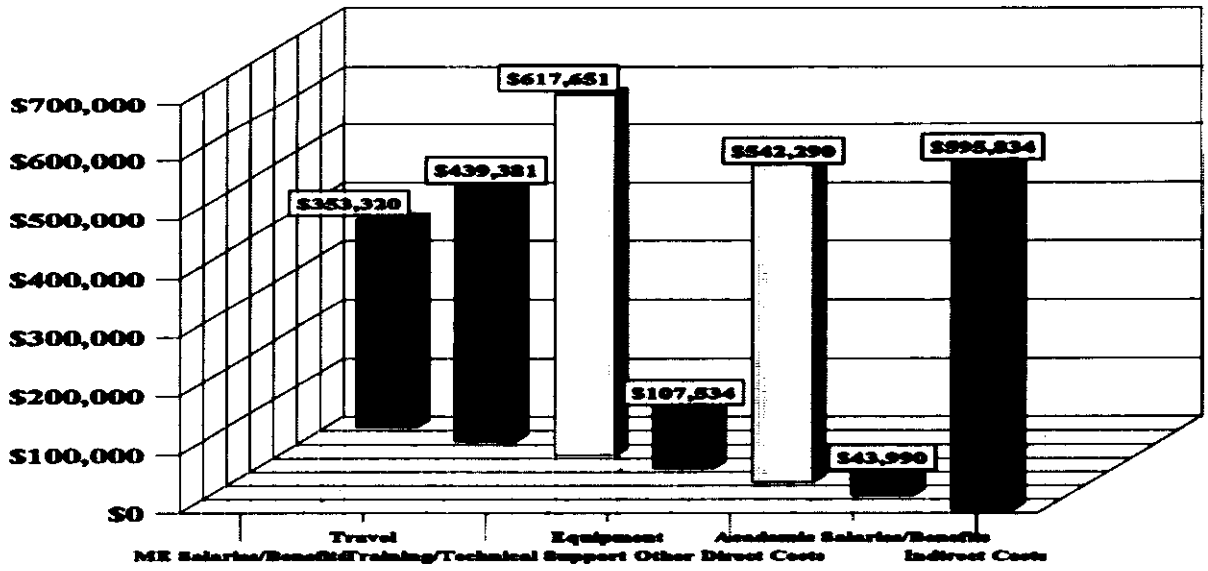
Breakdown of Buy-Ins
$ 1,701,671



FY 2001 INTSORMIL Budget Analysis
Year 22 - July 1, 2000 - June 30, 2001
Functional - $ 2,700,000

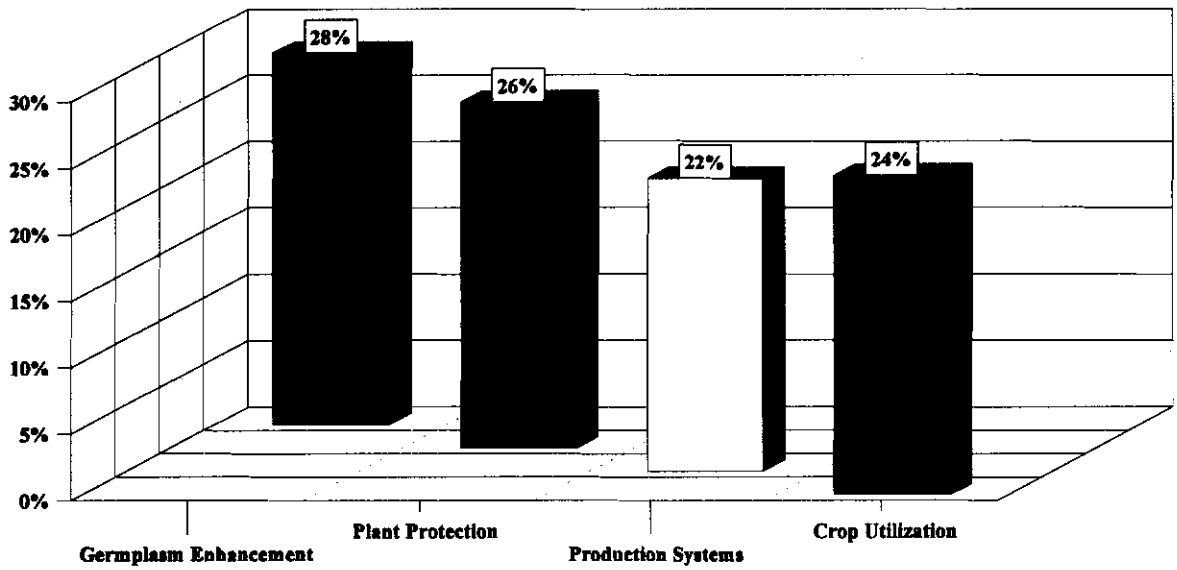


By Region

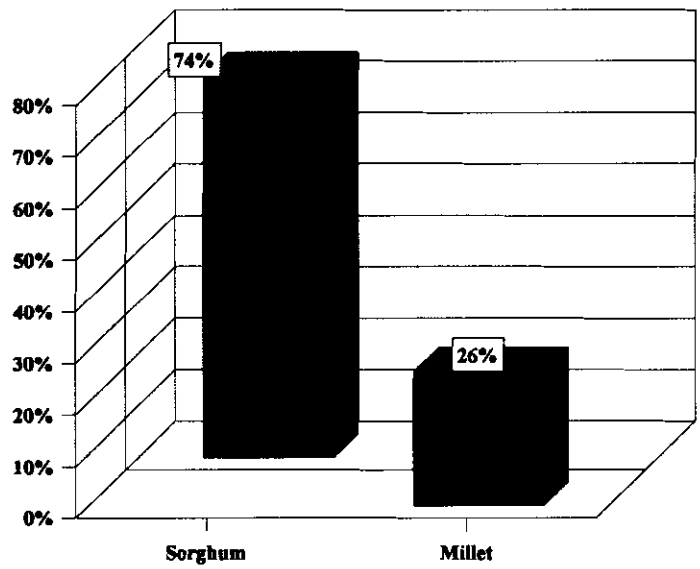


By Line Item

FY 2001 INTSORMIL Technical Budget Analysis
Year 22 - July 1, 2000 - June 30, 2001
$ 1,845,000



Technical Thrusts - By Percentage



Crops - By Percentage

Table 1. USAID-Grant contribution to Sorghum/Millet CRSP for all collaborative research and management entity for Years 1 (FY80) through 22 (FY 2001).

Budget Line Items	Years 1-20 FY 80-2000	Year 22 FY 2001	Totals FY 80 - FY 2001
Salaries / Benefits	$ 24,919,503	$ 997,414	$ 25,916,917
Equipment / Facilities	2,690,771	91,534	2,782,305
Travel	6,716,938	345,896	7,062,834
Other Direct Costs	6,434,529	454,322	6,888,851
Special Projects	4,982,276	215,000	5,197,276
Indirect Costs	13,856,865	595,834	14,452,699
Sub Total	**$ 59,600,882**	**$ 2,700,000**	**$ 62,300,882**
Mission Buyin	771,432		771,432
Total	**$ 60,372,314**	**$ 2,700,000**	**$ 63,072,314**

Table2. Management Entity office budget details for Years 1 (FY 80) through 22 (FY 2001).

	Years 1-21	Year 22	Totals
Salaries/Benefits	$ 3,899,859	$ 353,320	$ 4,253,179
Equipment	56,234	1,500	57,734
Travel	973,256	55,000	1,028,256
Consultation	44,600		44,600
Other Direct Costs	534,971	39,000	573,971
Iindirect Costs	2,252,106	191,180	2,443,286
Sub Total	**$ 7,761,026**	**$ 640,000**	**$ 8,401,026**
Workshops	151,000	15,000	166,000
EEP	295,000	1,000	296,000
Special Projects	482,800	199,000	681,800
Total	**$ 8,689,826**	**$ 855,000**	**$ 9,544,826**

Table 3. Summary of non-federal matching contributions by U.S. institutions - Years 1 (FY80) through 22 (FY 2001).

U.S. Institution	Years 1-21	Year 22	Totals
University of Arizona	$ 149, 310		$ 149,310
Florida A&M University	23,898		23,898
University of Kentucky	215,649		215,649
Kansas State University	1,890,399	40,000	1,930,399
Mississippi State University	993,619	18,750	1,012,369
University of Nebraska	2,440,947	40,600	2,481,547
Purdue University	3,248,674	166,993	3,415,667
Texas A&M University	5,018,597	124,037	5,142,634
University of Illinois - Urbana-Champaign	60,410	24,872	85,282
USDA	5,300	10,610	15,910
Totals	**$ 14,046,803**	**$ 425,862**	**$14,472,665**

Table 4a. USAID grant contribution to Sorghum/Milet CRSP for all collaborative research for participating institutions. Year 22 (FY 2001) July 1, 2000 - June 30, 2001. USAID Grant LAG-G-00-96-90009-00.

	IL	KS	MS	NE	PR	TX	USDA	Inst Total
Salary*	$ 26,615	$ 39,316	$ 32,927	$ 50,416	$ 221,393	$ 152,977	$ 52,150	$ 575,794
Equipment		2,000	3,858	23,000	3,500	11,176		43,534
Travel	13,308	23,304	13,800	21,000	78,684	58,200	4,000	212,296
ODC	6,594	8,488	3,550	34,917	136,730	61,453	7,490	259,222
Indirect Costs	23,483	26,892	20,865	35,667	180,193	111,194	6,360	404,654
Total	**$ 70,000**	**$ 100,000**	**$ 75,000**	**$ 165,000**	**$ 620,500**	**$ 395,000**	**$ 70,000**	**$ 1,495,500**

*Academic, Post Doc, Technical Staff, Graduate Stipends, and hourly staff.

Table 4b. USAID grant contribution to Sorghum/Milet CRSP for all collaborative research for special projects, regional projects and the management entity. Year 22 (FY 2001) July 1, 2000 - June 30, 2001. USAID Grant LAG-G-00-96-90009-00.

	ME special projects	ME regional projects	Management Entity	Institutional Totals from Table 4a.	Total
Salary*	$ 17,547	$ 68,300	$ 353,320	$ 575,794	$ 1,014,961
Equipment	16,000	46,500	1,500	43,534	107,534
Travel	93,485	78,600	55,000	212,296	439,381
ODC	87,968	156,100	39,000	259,222	542,290
Indirect Costs			191,180	404,654	595,834
Total	**$ 215,000**	**$ 349,500**	**$ 640,000**	**$ 1,495,000**	**$ 2,700,000**

*Academic, Post Doc, Technical Staff, Graduate Stipends, and hourly staff.

Year 22 Degree Education

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

The most frequently used mode of educational activities 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, 33 students from 17 different countries were enrolled in an INTSORMIL advanced degree program. Approximately 51% of these students come from countries other than the USA which shows the emphasis placed on host country institutional development (Figure 1).

INTSORMIL also places a high priority on educating women which is reflected in Figure 2. In 2000-2001, 27% of all INTSORMIL graduate participants were female. Thirteen of the 33 students received full INTSORMIL scholarships and an additional 20 students received partial INTSORMIL funding as shown in Figure 3.

All 33 students worked directly with INTSORMIL principal investigators on INTSORMIL projects. These students are enrolled in graduate programs in six disciplinary areas, agronomy, breeding, pathology, entomology, food quality, and economics.

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 1993-1994, there were 25 U.S. PIs with the program and in 2000-2001 there were 14.

Degree programs and short-term programs have been designed and implemented on a case by case basis to suit the needs of host country scientists. Four post doctoral scientists and 14 visiting host country scientists were provided the opportunity to upgrade their skills in this fashion during 2000-2001.

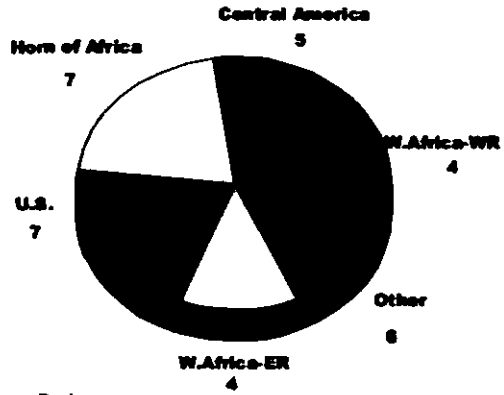


Figure 1. Degree participants by region.

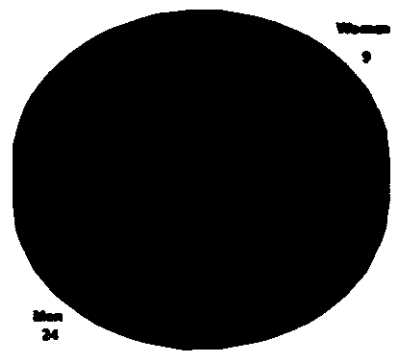


Figure 2. Degree participants by gender.

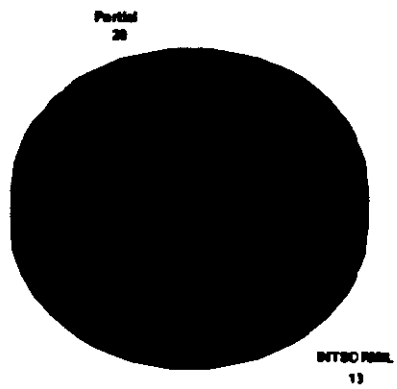


Figure 3. Degree participants source of funding.

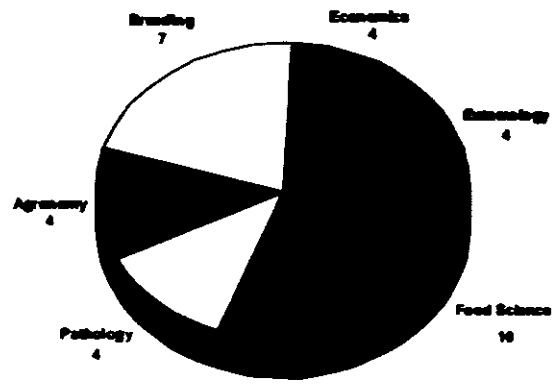


Figure 4. Degree participants by discipline breakdown.

Year 22 INTSORMIL Degree Training Participants July 1, 2000 - June 30, 2001

Name	Country	Univ.	Discipline	Advisor	Degree	Gender	Funding
Regassa, Teshome	Ethiopia	UNL	Agron/Physiol	Maranville	PHD	M	P
Kathol, Delon	U.S.	UNL	Agronomy	Mason	MSC	M	P
Maman, Nouri	Niger	UNL	Agron/Physiol	Mason	PHD	M	P
Seibou, Pale	Burkina Faso	UNL	Agronomy	Mason	MSC	M	I
Nduulu, Lexingtons	Kenya	PRF	Breeding	Axtell	PHD	M	I
Ellicott, Alexis	U.S.	PRF	Genetics/Breeding	Ejeta	PHD	F	P
Gunaratna, Nilupa	U.S.	PRF	Breeding	Ejeta	MSC	F	I
Mohammed, Abdalla	Sudan	PRF	Breeding	Ejeta	PHD	M	I
Phillips, Felicia	U.S.	PRF	Breeding	Ejeta	MSC	F	P
Coulibaly, Sidi Bekaye	Mali	TTU	Breeding	Rosenow/Peterson	PHD	M	P
Teme, Niaba	Mali	TTU	Breeding	Rosenow	MSC	M	I
Asante, Victor	Ghana	PRF	Economics	Sanders	MSC	M	P
Kazianga, Harounan	Burkina Faso	PRF	Economics	Sanders	PHD	M	P
Tahirou, Abdoulaye	Niger	PRF	Economics	Sanders	PHD	M	I
Wubeneh, Nega G.	Ethiopia	PRF	Eonomics	Sanders	MSC	M	I
Gorena, Roberto Luis	U.S.	TAM	Entomology	Peterson/Teetes	PHD	M	I
Jensen, Andrea	U.S.	TAM	Entomology	Teetes	PHD	F	P
Carrillo, Mario	Argentina	MSU	Entomology	Pitre	MSC	M	I
Johnson, Zeledon	Nicaragua	MSU	Entomology	Pitre	PHD	M	I
Bugusu, Betty	Kenya	PRF	Food Quality/Util	Hamaker	PHD	F	I
Maladen, Michelle	India	PRF	Food Quality/Util	Hamaker	MSC	F	I
Mix, Nadege	France	PRF	Food Quality/Util	Hamaker	MSC	F	I
Suhendra, Budhi	Indonesia	PRF	Food Quality/Util	Hamaker	MSC	M	P
Awika, Joseph Mobutu	Kenya	TAM	Food Quality/Util	Rooney/Waniska	MSC	M	P
Awika, Joseph Mobutu	Kenya	TAM	Food Quality/Util	Rooney/Waniska	PHD	M	P
Bueso, Francisco (Javier)	Honduras	TAM	Food Quality/Util	Rooney/Waniska	PHD	M	P
Gordon, Leigh Ann	U.S.	TAM	Food Quality/Util	Rooney	MSC	F	P
Mitre-Dieste, Marcelo	Mexico	TAM	Food Quality/Util	Rooney	MSC	M	P
Zelaya, Nolvia	Honduras	TAM	Food Quality/Util	Rooney/Waniska	MSC	F	P
Narvaez, Dario	Colombia	KSU	Pathology	Claflin	PHD	M	P
Salah, Amgad	Egypt	KSU	Pathology	Leslie	PHD	M	P
Kollo, Issoufou	Niger	TAM	Pathology	Frederiksen	PHD	M	P
Montes, Noe	Mexico	TAM	Pathology	Odvody/Isakeit	PHD	M	P

- I = Completely funded by INTSORMIL
  P = Partially funded by INTSORMIL
  IC = InterCRSP Funding

KSU = Kansas State University
MSU= Mississippi State University
PRF = Purdue University
TAM= Texas A&M University
TTU = Texas Tech University
UNL = University of Nebraska - Lincoln
USDA= Tifton, Georgia

Year 22 INTSORMIL Non-Degree Educational Activities July 1, 2000 - June 30, 2001

Name	Country	Univ.	Discipline	Advisor	Activity	Gender	Funding
Grenier, Cecile	France	PRF	*Striga* Physiology	Ejeta	VS	F	P
Rich, Patrick	U.S.	PRF	*Striga* Biology	Ejeta	PD	M	I
Mogorosi, Michael	Botswana	USDA	Breeding	Hanna	VS	M	I
Sanogo, Moussa	Mali	USDA	Breeding	Hanna	VS	M	I
Teme, Niaba	Mali	TAM	Breeding	Rosenow	VS	M	P
Toure, Aboubacar	Mali	TAM	Breeding	Rosenow	VS	M	I
Bittaye, Alieu	Gambia	PRF	Economics	Sanders	VS	M	P
Aboubacar, Adam	Niger	PRF	Food Quality/Util	Hamaker	PD	M	P
Herrera, Fidelia	El Salvador	TAM	Food Quality/Util	Rooney/Waniska	VS	F	I
dos Santos, Claudia	Brazil	KSU	Pathology	Claflin	VS	F	P
Guzman, Reina	El Salvador	KSU	Pathology	Claflin	VS	F	I
Lemoine, Benoit	France	KSU	Pathology	Claflin	VS	M	P
Pichardo, Sergio	Nicaragua	KSU	Pathology	Claflin	VS	M	I
Seabra, Maria	Brazil	KSU	Pathology	Claflin	VS	F	P
Chulze, Sofia	Argentina	KSU	Pathol/Mycology	Leslie	VS	F	P
Jurgenson, Jim	U.S.	KSU	Pathol/Genetics	Leslie	VS	M	P
Kerenyi, Zoltan	Hungary	KSU	Pathol/Genetics	Leslie	PD	M	P
Zeller, Kurt P.	U.S.	KSU	Pathology	Leslie	PD	M	P

VS = Visiting Scientist
PD = Post Doctoral

Year 22 Conference/Workshop Activities July 1, 2000 - June 30, 2002

Workshop/Conference	Location	Date	Participants		
			Male	Female	Total
ROCARS Mid-Term Network Evaluation	Bamako, Mali	April 21-28, 2001	1		1
Fusarium Workshop	Manhattan, KS	June 10-15, 2001	15	14	29
Scientific Writing Workshop	Tygerberg, South Africa	Dec. 11, 2000	10	13	23
West Africa/Western Region Planning Meeting	Bamako, Mali	Nov. 5-11, 2000	4		4
Scientific Writing Workshop	Penang, Malaysia	Nov. 13-16, 2000	64	33	97
Scientific Writing Workshop	Dokki, Egypt	Oct. 18, 2000			
		April 29-30, 2001	80	40	120
Scientific Writing Workshop	Kampala, Uganda	Oct. 12, 2000	38	27	65
Global 2000: Sorghum and Pearl Millet Diseases III	Guanajuato, Mexico	Sept. 23-30, 2000	112	28	140
Total			324	155	479

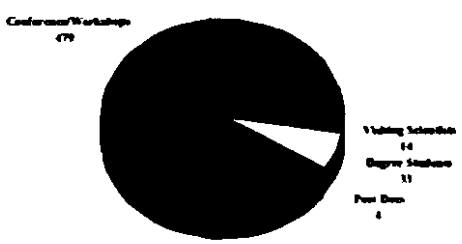


Figure 5. Total participants in educational activities.

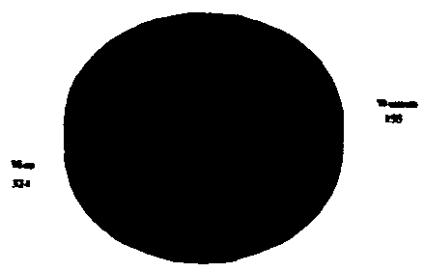


Figure 6. Total conference/workshop participants by gender.

INTSORMIL Buyins - FY 2001

ARS-204	University of Georgia	$ 55,000	$ 55,000
KSU-210A	Kansas Agricultural Experiment Station	17,000	
	IIE/USAID (Cairo	27,606	
	USDA-National Scab Research Initiative	13,000	
	USAID (Cairo) ATUT Program	15,000	
	American Society for Microbiology	20,000	
	USDA-National Scab Research Initiative	60,000	
	USDA - National Scab Research Initiative	53,000	
KSU-210B	USDA/ARS	19,760	
	North Central Region	14,000	
	Kansas Agricultural Experiment Station	15,000	
	Pioneer Hybrid International	16,000	270,366
PRF-205	USAID/Africa/SD	112,000	
	University of Hawaii	5,396	
PRF-209	Winrock International	15,000	
	McKnight Foundation	10,000	
PRF-212	Mahyco Research Foundation	30,000	
	Pacific Seeds Pty Ltd.	21,600	
PRF-213	Rockefeller Foundation	80,000	
	USAID/ICRISAT	29,000	302,996
TAM-222	Sorghum Biotech Partnership	10,000	
	USDA-ARS	8,000	
	National Grain Sorghum Producers	12,500	
	Rockefeller Foundation (Mali - West Africa Project)	40,000	
TAM-223	PROFIT Initiative (TAES)	40,000	
	PROFIT Initiative (TAES)	20,380	
TAM-226	Hatch H-6789	35,000	
	Hatch H-7134, NC-213	70,000	
	Texas Grain Sorghum Producers Board	50,000	
	Texas Higher Education/ATP	51,250	
	PROFIT Initiative (TAES)	24,000	
	PROFIT Initiative (TAES)	19,500	
TAM-228	USDA-ARS	48,000	428,630
UNL-213	Anna Elliott Foundation	15,000	
	University of Nebraska	18,000	
UNL-214	Pioneer Hybrid International	20,000	53,000
Management	USAID/Mozambique Training Grant	591,679	591,679
	Total Buyins - July 1, 2000 to June 30, 2001- FY 01 - Year 22		**$ 1,701,671**

INTSORMIL Sponsored and Co-Sponsored Workshops 1979 - 2001

	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.	Agrimeteorology 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.	Striga 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 '80s	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 National Sobre Produccion y Utilizacion del Sorgo	Santo Domingo, Dominican Republic	2/84
22.	Evaluating Sorghum for Al 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.	Maicillos Criollos and Other Sorghum in Middle America Workshop	Tegucigalpa, Honduras	12/87
31.	INTSORMIL PI Conference	Kansas City, Missouri	1/87
32.	2nd Global Conference on Sorghum/Millet Diseases	Harare, Zimbabwe	3/88
33.	6th Annual CLAIS Meeting	San Salvador, El Salvador	12/88
34.	International INTSORMIL Research Conference	Scottsdale, Arizona	1/89
35.	INTSORMIL Graduate Student Workshop and Tour	College Station, Texas	7/89
36.	ARC/INTSORMIL Sorghum/Millet Workshop	Wad Medani, Sudan	11/89
37.	Workshop on Sorghum Nutritional Grain Quality	West Lafayette, Indiana	2/90
38	Improvement and Use of White Grain Sorghums	El Batan Mexico	12/90
39.	Sorghum for the Future Workshop	Cali, Colombia	1/91
40.	INTSORMIL PI Conference	Corpus Christi, Texas	7/91
41.	Social Science Research and the CRSPs	Lexington, KY	6/92
42.	Seminario Internacional Sobre los Cultivos de Sorgo y Maiz sus Principales Plagas y Enfermedades	Colombia	1/93
43.	Workshop on Adaptation of Plants to Soil Stresses	Lincoln, NE	8/93
44.	Latin America Workshop on Sustainable Production Systems for Acid Soils	Villavicencio, Colombia	9/93
45.	Latin America Sorghum Research Scientist Workshop (CLAIS Meeting)	Villavicencio, Colombia	9/93
46.	Disease Analysis through Genetics and Biotechnology: An International Sorghum and Millet Perspective	Bellagio, Italy	11/93
47.	INTSORMIL PI Conference	Lubbock, Texas	9/96
48.	International Conference on Genetic Improvement of Sorghum and Pearl Millet	Lubbock, Texas	9/96
49.	Global Conference on Ergot of Sorghum	Sete Lagoas MG Brazil	6/97
50.	Conference on the Status of Sorghum Ergot in North America	Corpus Christi, Texas	6/98
51.	Principal Investigators Meeting and Impact Assessment Workshop	Corpus Christi, Texas	6/98

	Name	Where	When
52.	Regional Hybrid Sorghum and Pearl Millet Seed Workshop	Niamey, Niger	9/98
53.	INTSORMIL End Use Quality Assessment Workshop	Pretoria, South Africa	12/98
54	Central America Regional Planning Workshop	Zamorano, Honduras	10/99
55.	Global 2000 Conference, Sorghum and Pearl Millet Diseases III	Guanajuato, Mexico	9/00

Bibliographies

Sustainable Plant Protection Systems

Journal Articles & Book Chapters.

Chulze, S. N., A. Torres, M. L. Ramirez & J. F. Leslie. 2000. Genetic variation in *Fusarium* section *Liseola* from no-till maize in Argentina. *Applied and Environmental Microbiology* **66**: 5312-5315.

Claflin, L. E. 2000. Procaryotic diseases and stalk rots of grain sorghum diseases. *In*, R. A. Fredericksen and G. N. Odvody, eds., Sorghum Disease Compendium, 2nd ed. pp. 5-7, 28-30. American Phytopathological Soc., St. Paul, MN.

Claflin, L. E. 2000. Ergot: A new disease of grain sorghum in the Western Hemisphere. Revista Mexicana de Fitopathologia. 17:46-48.

Cordero, R.J., R.L. Brown, and H.N. Pitre. 2000. Description of life stages and distribution of *Metaponpneumata rogenhoferi* (Lepidoptera: Noctuidae). Tropical Lepidoperta. 10: 59-67.

Leslie, J. F. 2000. Storage molds and mycotoxicoses. In: *Compendium of Sorghum Diseases* (R. A. Frederiksen & G. N. Odvody, eds.), pp. 42-43. APS Press, St. Paul, Minnesota. 78 pp.

Leslie, J. F. 2000. *Fusarium* species associated with sorghum. In: *Compendium of Sorghum Diseases* (R. A. Frederiksen & G. N. Odvody, eds.), pp. 30-31. APS Press, St. Paul, Minnesota. 78 pp.

Lopez, J.I., H.N. Pitre, and D.H. Meckenstock. ____. Changes in fall armyworm (Lepidoptera: Noctuidae) fitness over five generations after larval feeding on resistant tropical landrace sorghum. Ceiba. 40: 2 ____. (accepted)

Lopez, J.I., H.N. Pitre and D.H. Meckenstock. ____. Influence of nitrogen fertilzer on resistance to fall armyworm (Lepidoptera: Noctuidae) in tropical Honduran landrace sorghum. Ceiba. 40: 2 ____. (accepted)

Mohammed, A., G. Ejeta, and T. Housley. 2001. *Striga* asiatica seed conditioning and 1-aminoacylopropane-1-carboxylate oxidase activity. Weed Research 41:165-176.

Nzioki, H. S., L. E. Claflin, and B. A. Ramundo. 2000. Evaluation of screening protocols to determine genetic variability of grain sorghum germplasm to *Sporisorium sorghi* under field and greenhouse conditions. Int. J. Pest Management 46:91-95.

Steenkamp, E. T., B. D. Wingfield, T. A. Coutinho, K. A. Zeller, M. J. Wingfield, W. F. O. Marasas & J. F. Leslie. 2000. PCR-based identification of *MAT-1* and *MAT-2* in the *Gibberella fujikuroi* species complex. *Applied and Environmental Microbiology* **66**: 4378-4382.

Vergara, O.R. and H.N. Pitre. ____. Planting data, weed management and insecticide application practices for control of lepidopterous pests in intercropped sorghum and maize in southern Honduras. Tropical Agriculture. (accepted)

Vergara, O.R. and H.N. Pitre. ____. Complexity of intercropped sorghum-maize production systems in southern Honduras. Ceiba. 40: 2 ____. (accepted)

Zeller, K. A., J. E. Jurgenson, E. M. El-Assiuty & J. F. Leslie. 2000. Isozyme and amplified fragment length polymorphisms (AFLPs) from *Cephalosporium maydis* in Egypt. *Phytoparasitica* **28:** 121-130.

Books, Book Chapters and Proceedings

Collins, S.D., P.J. Mehta, W.L. Rooney, D.T. Rosenow, and G.N. Odvody. 2001. New Disease Resistant Converted Sorghum Lines. p85-86 in Proceedings of the 22nd Biennial Grain Sorghum Research and Utilization Conference. February 18-20, 2001, Nashville, TN.

Ejeta, G., A. Babiker, K. Belete, P. Bramel, A. Ellicott, C. Grenier, T. Housley, I. Kapran, A. Mohamed, P. Rich, C. Shaner, and T. Toure. 2001. Breeding for Durable Resistance to *Striga* in Sorghum. p. 166. In:Fer et al. (eds) Proceedings of the 7th International Parasitic Weed Symposium. 5-8 June, Nantes, France.

Ejeta, G. 2000. *Striga*: Noxious Parasitic Weeds of Tropical Cereals and Legumes. p. 53-57. In: R.A. Frederiksen and G.N. Odvody (eds.) Compendium of Sorghum Diseases. APS Press.

Ejeta, G. 2000. Genetic approaches to the control of *Striga* in sorghum and millets. In: Leslie and Frederiksen (eds.) Global 2000 Sorghum and Pearl Millet Diseases Conference. 23-30 September, Guanajuato, Mexico.

Frederickson, D. E., and G. N. Odvody. 2000. Survival of inoculum of *Claviceps africana* in Zimbabwe: Potential sources of initial inoculum in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Frederiksen, R.A. and G. N. Odvody, Editors, Compendium of Sorghum Diseases, Second Edition. 2000. 78 pp, APS Press, American Phytopathological Society, St Paul, MN, September 2000.

Grenier, C., P.J. Rich, A. Mohammed, A. Ellicott, C. Shaner and G. Ejeta. 2001. Independent Inheritance of lgs and IR Genes in Sorghum. In:Fer et al. (eds) Proceedings of the 7th International Parasitic Weed Symposium. 5-8 June, Nantes, France.

Mohamed, A.H., G. Ejeta, and T.L. Housley. 2001. Control of *Striga* Seed Germination. p. 125. In:Fer et al. (eds) Proceedings of the 7th International Parasitic Weed Symposium. 5-8 June, Nantes, France.

Mohamed, A., A. Ellicott, C. Grenier, P.J. Rich, C. Shaner, and G. Ejeta. 2001. Hypersensitive Resistance to *Striga* in Sorghum. p. 204-206. In:Fer et al. (eds) Proceedings of the 7th International Parasitic Weed Symposium. 5-8 June, Nantes, France.

Montes, N., G. N. Odvody and M . Marin Silva. 2000. Effect of Cold degree units on Incidence of Claviceps africana in sorghum hybrids in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Montes, N., G. N. Odvody and H. Williams. 2000. Relationship Between Climatic Variables and C.africana incidence on sorghum hybrids in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Montes, N., G. N. Odvody, and H.Williams. 2000.Advances in *Claviceps africana* chemical control in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Moran, J. L., W.L.Rooney, R.A. Frederiksen, and G.Odvody. 2000. Differences in ergot variability among sorghum genotypes and the relationship between stigma receptivity and ergot vulnerability in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Odvody, G. N., D.E. Frederickson, T. Isakeit, N. Montes, J. A. Dahlberg and G. L. Peterson. 2000. Quarantine Issues arising from Contamination of Seed with Ergot: An Update in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Odvody, G. N., N. Montes, D. Frederickson and J. Narro. 2000. Detection of sclerotia of *Claviceps africana* in the western hemisphere in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Odvody, G., D. E. Frederickson, T. Isakeit, J. A. Dahlberg and G. L. Peterson. 1999. The role of seedborne inoclum in sorghum ergot. p. 136-140 in Proceedings of 3rd International Seed Health Symposium August 16-19, 1999, Ames, IA

Rodriguez-Ballesteros, O. R., A. S. B Mansuetus, R. D. Waniska, R. A. Frederiksen, G. N. Odvody and D. T. Rosenow. 2000. Free and bound phenolic acids in mature sorghum caryopsis as affected by inoculation with Fusarium thapsinum in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Rosenow, D. T., N. Teme, G.C. Peterson, C.A. Woodfin, and G.N. Odvody, 2001. Association of Stay Green with Lodging and Charcoal Rot. p91-92 in Proceedings of the 22nd Biennial Grain Sorghum Research and Utilization Conference. February 18-20, 2001, Nashville, TN.

Rosenow, D. T., N. Teme, C.A. Woodfin, G.N. Odvody, and G.C. Peterson. 2000. Relationship of Stay Green with Charcoal Rot and Lodging in Sorghum in Proceedings of Global 2000: Sorghum and Pearl Millet Diseases III September 23-30, 2000. Guanajuato, Mexico: In Press

Dissertations and Theses

M.S. Thesis

Zeledon, J.J. 2000. Occurrence, host plant relationships and management of sorghum midge, *Stenodiplosis sorghicola* (Coq.) (Diptera: Cecidomyiidae), on sorghum in Nicaragua. M.S. thesis. Mississippi State University, Mississippi State, MS.

Miscellaneous Publications

Claflin, L. E. 2000. Agroecology and biotechnology of fungal pathogens of sorghum and millet from the Greater Horn of Africa. Pp. 11-18 in INTSORMIL Ann. Repts., A Technical Res. Rept. of the Grain Sorghum/Pearl Millet Collaborative Res. Support Prog. (CRISP), University of Nebraska, Lincoln.

Collins, S. D., W. L. Rooney, T. Isakeit, G. N. Odvody & K. Schaefer.Grain mold and grain weathering reactions of grain sorghum hybrids, 1999. 2000. Biological & Cultural Tests: In Press

Zeledon, J., H. Pitre, J. Vanegas and H. Obregon. 2000. La mosquita de la panaja del. sorgo. Centro Nacional de Investigaciones Agropecuarias. 6 pp.

Abstracts

Jurgenson, J. E., R. L. Bowden, K. A. Zeller & J. F. Leslie. 2000. AFLP Linkage map of *Gibberella zeae*. *Phytopathology* **90:** s40.

Leslie, J. F. & K. A. Zeller. 2000. AFLPs for distinguishing populations and species of *Fusarium*. *Phytopathology* **90:** s46.

Mohamed, A.H., P.J. Rich, T.L. Housley, and G. Ejeta. 2000. Mechanisms of *Striga* resistance in sorghum. Agron. Abs. p. 111.

Ramundo, B.A., L.E. Claflin., and D.F. Narvaez. 2000. Identification of *Burkholderia andropogonis* Using PCR Generated Genomic Fingerprints. Global 2000: Sorghum and Pearl Millet Diseases lll. Guanajuato, Mexico.

Saleh, A. A., K. A. Zeller, E. M. El-Assiuty & J. F. Leslie. 2000. AFLP diversity of *Cephalosporium maydis* in Egypt. *Phytopathology* **60:** s68.

Zeller, K. A., R. L. Bowden & J. F. Leslie. 2000. AFLP diversity of *Fusarium graminearum* (*Gibberella zeae*) in two wheat-scab epidemic populations. *Inoculum* **51(3)**: 69.

Zeller, K. A., E. M. El-Assiuty & J. F. Leslie. 2000. Relative colonization ability of maize by four lineages of *Cephalosporium maydis* from Egypt. *Inoculum* **51**(3): 69.
Book Reviews

Leslie, J. F. *Structure and Dynamics of Fungal Populations*; ed. J. J. Worrall; Kluwer Academic Publishers, Norwell, Massachusetts, 348 pp. Reviewed in *Mycopathologia* **147**(2000): 169-170.

Sustainable Production Systems

Journal Articles

Coulibaly, A., M. Bagayoko, S. Traoré and S.C. Mason. 2000. Effect of crop residue management and cropping system on pearl millet and cowpea yield. Afri. Crop Sci. J. 8(4):1 - 8.

Maranville, J.W. and S. Madhavan. 2001. Physiological adaptations for nitrogen use efficiency in sorghum. Plant Soil (in press).

Pandey, R.K., J.W. Maranville, and Y. Bako. 2001. Nitrogen fertilizer response and use efficiency for three cereal crops in Niger. Comm. Soil Sci. Plant Anal. 32:1465-1482.

Pandey, R.K., T.W. Crawford, Jr., and J.W. Maranville. 2001. Agriculture intensification and ecologically sustainable land use in Niger: A case study of evolution of intensive systems with supplementary irrigation. J. Sust. Agric. (In press).

Pandey, R.K., J.W. Maranville, and S. Sirifi. 2001. Comparison of nitrogen use efficiency of a newly developed sorghum hybrid and two improved cultivars in the Sahel of West Africa. J. Plant Nut. (In press).

Samba Traoré, J. L. Lindquist, A. R. Martin, S. C. Mason and D.A. Mortensen. 2001. Comparative ecophysiology of grain sorghum *(Sorghum bicolor) and Abutilon theophrasti* in monoculture and in mixture. Weed Res. 40: (In Press).

Book Chapters and Proceedings

Ahmed, Mohamed M., John H. Sanders, and Wilhelm T. Nell. 2001. "New Sorghum and Millet Cultivar Introduction in Sub-Saharan Africa: Impacts and Policy Implications." In: I. Akintayo and J. Sedego (eds.), *Towards Sustainable Sorghum Production, Utilization, and Commercialization in West Central Africa*, proceedings of a technical workshop of the West and Central Africa Sorghum Research Network, pp. 283-295. Bamako, Mali: ICRISAT.

Sanders, John H., and Mohamed Ahmed. 2001. "Developing a Fertilizer Strategy for Sub-Saharan Africa," Ch. 16. In: *Sustainability of Agricultural Systems in Transit*. ASA Special Publication. Madison, WI: American Society of Agronomy, Crop Science Society of America, and Soil Science Society of America, forthcoming.

Shapiro, Barry I., and John H. Sanders. 2001. "Natural-Resource Technologies for Semiarid Regions of Sub-Saharan Africa." In: Christopher B. Barrett, Frank M. Place, and Abdillahi Aboud (eds.), *Natural Resources Management in African Agriculture: Understanding and Improving Current Practices.* Tucson, AZ: CAB International of North America, forthcoming.

Dissertations and Theses

Ph.D. Degrees

Sidibé, Mamadou, "A Farm Household Analysis of Technological Change and Structural Adjustment Policies in the Peanut Basin of Senegal," Ph.D., 2000.

Vitale, Jeffrey D., "The Economic Impacts of New Sorghum and Millet Technologies in Mali," Ph.D., 2001.

Miscellaneous Publications

Coulibaly, A., S. Traoré, M. Bagayoko and S.C. Mason. 2000. Intercropping millet with maize. In J. Slaats and O. Niangado (eds.). Technology leaflets: Agricultural Research Station Cinzana. IER - Syngenta Foundation.

Coulibaly, A., S. Traoré, M. Bagayoko and S.C. Mason. 2000. Soil fertility management in millet cropping system. In J. Slaats and O. Niangado (eds.). Technology leaflets: Agricultural Research Station Cinzana. IER - Syngenta Foundation.

Coulibaly, A., S. Traoré, M. Bagayoko and S.C. Mason. 2000. Establishing cowpea rotation crop in millet cropping system. In J. Slaats and O. Niangado (eds.). Technology leaflets: Agricultural Research Station Cinzana. IER - Syngenta Foundation.

Coulibaly, A., S. Traoré, M. Bagayoko and S.C. Mason. 2000. Intercropping millet with cowpea. In J. Slaats and O. Niangado (eds.). Technology leaflets: Agricultural Research Station Cinzana. IER - Syngenta Foundation.

Coulibaly, A., S. Traoré, M. Bagayoko and S.C. Mason. 2000. Intercropping millet with groundnut. In J. Slaats and O. Niangado (eds.). Technology leaflets: Agricultural Research Station Cinzana. IER - Syngenta Foundation.

IGAD/INTSORMIL/USAID-REDSO. 2001. *Agricultural Technology for the Semiarid African Horn*, Vol. 1: *Synthesis Report*," John H. Sanders and Della E. McMillan (eds). Lincoln, NE: INTSORMIL.

__, Vol. 2: *Country Studies: Djibouti. Eritrea, Ethiopia, Kenya, Sudan, and Uganda*, John H. Sanders and Della E. McMillan (eds.). Lincoln, NE: INTSORMIL.

Wubeneh, Nega, and John H. Sanders, "Diffusion of *Striga*-Resistant Cultivars in Tigray, Ethiopia: A Preliminary Report to INTSORMIL," Progress Report made to INTSORMIL on field activities, April 2001, 10 pages.

Abstracts

Kathol, D.P., T.D. Galusha and S.C. Mason Comparison of "New" and "Old" Maize and Sorghum Hybrids. Agron. Abstracts (In Press).

Maman, N., S.C. Mason and S. Fernandez-Rivera. 2001. Growing Season Pearl Millet Tiller Harvest as a Potential Forage Source in Niger. Agron. Abstracts (In Press).

Mason, S.C. and R.P. Waldren. 2001. A decade of globalizing a crop management course. NACTA J. 45: (In Press).

Germplasm Enhancement and Conservation

Journal Articles

Cisse, N., and G. Ejeta. 2001. Genetic variation and relationships among seedling vigor traits in sorghum. Crop Sci. (In Press).

King, D., M.Z. Fan, G. Ejeta, A. Asem, and O. Odeola. 2000. The effects of tannins on nutrient utilization in the White Pekin duck. British Poultry Science 41:630-639.

Rodriguez-Herrera, R., W.L. Rooney, D.T. Rosenow, and R.A. Frederiksen. 2000. Inheritance of grain mold resistance in grain sorghum without a pigmented testa. Crop Science 40:1573-1578.

Xu, W., D.T. Rosenow, and H.T. Nguyen. 2000. Stay green trait in grain sorghum: relationship between visual rating and leaf chlorophyll concentration. Plant Breeding 119: 365-367.

Chopra, S., V. Brendel, J. Zhang, J.D. Axtell, and T. Peterson. 1999. Molecular characterization of a mutable pigmentation phenotype and isolation of the first active transposable element from Sorghum bicolor. Proc. National Academy of Sci. 96(26):15330-15335.

Jenks, Matthew A., D. Rhodes, C. Ding, E.N. Ashworth, J.D. Axtell, and P.J. Rich. 2000. A novel class of very-long-chain free carboxylic fatty acid mutants in Sorghum bicolor (L.) Moench. Plant Physiology (In preparation).

Books, Book Chapters and Proceedings

Ejeta, G.. Workshop on Raising Agricultural Productivity in the Tropics: Biophysical Challenges for Technology and Policy. Center for International Development at Harvard University, Cambridge, Massachusetts, 17-18 October 2000.

Frederiksen, R.A., and D.T. Rosenow. 2000. Breeding for disease resistance. p. 64-65. In: Compedium of Sorghum Diseases, Second Edition. APS Press. Ed. R.A. Frederiksen and G.N. Odvody. The American Phytopathological Society, St. Paul, Minnesota. 78 p.

Machado, S., E.D. Bynum, Jr., T.L. Archer, R.J. Lascano, J. Bordovsky, K. Bronson, D.M. Nesmith, E. Segarra, D.T. Rosenow, and G.C. Peterson. 2000. Spatial and temporal variability of sorghum and corn yield: interactions of biotic and abiotic factors. *In* Proc. of the 5th Int. Conv. on Precision Agriculture, Minneapolis, MN, July 16-19, 2000.

Merkle, M.G. and D.T. Rosenow. 2000. Pesticide injury. p. 60. In: Compendium of Sorghum Diseases, Second Edition. APS Press. Ed. R.A. Frederiksen and G.N. Odvody. The American Phytopathologcial Society, St. Paul, Minnesota. 78 p.

Oria, M.P., B.R. Hamaker, and J.D. Axtell. 2000. A highly digestible sorghum cultivar exhibits a unique folded structure of endosperm protein bodies. Proc. National Academy of Sciences USA 97(10):5065-5070.

Peterson, G.C., B.B. Pendleton, and G.L. Teetes. 2000. PROFIT - Productive Rotations On Farms In Texas: A New Paradigm for Sorghum Research and Information Delivery. *In* Proc. of Global 2000: Sorghum and Pearl Millet Diseases III. Guanajuato, Mexico, Sep. 23-30, 2000. (In Press).

Rosenow, D.T., and J.A. Dahlberg. 2000. Collection, Conversion, and Utilization of Sorghum. In C. Wayne Smith and Richard A. Frederiksen (Eds.). Sorghum: Evolution, History, Production and Technology, John Wiley and Sons, New York, N.Y. Pp. 309-328.

Rosenow, D.T. 2000. Genetic disorders. p. 59-60. In: Compendium of Sorghum Diseases, Second Edition. APS Press. Ed. R.A. Frederiksen and G.N. Odovody. The American Phytopatholgocial Society, St. Paul, Minnesota. 78 p.

Rosenow, D.T. 2001. Sorghum breeding - A global perspective. 2001. In Proc. Fourth Australia Sorghum Conference, February 5-9, 2001, Kooralbyn, QLD, Australia. (in press).

Subudhi, P.K., H.T. Nguyen, M.L. Gilbert, and D.T. Rosenow. 2000. Sorghum Improvement: Past Achievements and Future Prospects. In Manjit S. Kang (Ed.) Crop Breeding: New Challenges in the Next Century. Food Products Press (in press).

Tuinstra, M.R., T. Teferra, L.E. Claflin, R.G. Henzell, A. Borrell, N. Seetharama, G. Ejecta, and D.T. Rosenow. 2000. Breeding for resistance to root and stalk rot in sorghum. In Proc. Global 2000: Sorghum and Millet Diseases III. Sept. 23-30, 2000, Guanajuato, Mexico. Iowa State Press. (in press).

Tuinstra, M.R., T. Tefarra, L.E. Claflin, R.G. Henzell, A. Borrell, N. Seetharama, G. Ejeta, and D.T. Rosenow, 2001. Root and stalk rot resistance in sorghum. Pp. 32-34. In Proc. of the 22nd Biennial Grain Sorghum Research and Utilization Conference, Feb. 18-20, 2001. Nashville, Tennessee.

Miscellaneous Publications

Rosenow, D.T., J.A. Dahlberg, G.C. Peterson, L.E. Clark, J.W. Sij, A.J. Hamburger, P. Madera-Torres, and C.A. Woodfin. 1999. Release of 27 converted sorghum lines. International Sorghum and Millets Newsletter 40: 29-31.

Abstracts

Collins, S.D., P.J. Mehta, W.L. Rooney, D.T. Rosenow, and G.N. Odvody. 2001. New disease resistant converted sorghum lines. Pp. 86-86. In Proc. 22nd Biennial Grain Sorghum Research and Utilization Conference, February 18-20, 2001. Nashville, Tennessee.

Gunaratna, N. and G. Ejeta. 2000. Inheritance of seedling cold tolerance in sorghum. Agronomy Abs. p. 111.

Rosenow, D.T., N. Teme, G.C. Peterson, C.A. Woodfin, and G.N. Odvody. 2001. Association of stay green with lodging and charcoal rot. Pp. 91-92. In Proc. 22nd Biennial Grain Sorghum Research and Utilization Conference, February 18-20, 2001. Nashville, Tennessee.

Rosenow, D.T., N. Teme, C.A. Woodfin, G.N. Odvody, and G.C. Peterson. 2000. Relationship of stay green with charcoal rot and lodging in sorghum. In Proc. Global 2000: Sorghum and Millet Diseases III. Sept. 23-20, 2000. Guanajuato, Mexico. Iowa State Press. (in press).

Crop Utilization and Management

Journal Articles

Aboubacar, A., Axtell, J.D., Huang, C.P., Hamaker, B.R. 2001. A rapid protein digestibility assay for identifying highly digestible sorghum lines. *Cereal Chem.* 78:160-165.

Barragan-Delgado, M.L. and S.O. Serna-Saldivar. 2000. Production and nutritional evaluation of liquefied weaning foods from malted sorghum, quality protein maize and other cereals. Cereal Chem. 77(5): 652-656.

Beta, Trust, Harold Corke, Lloyd W. Rooney, and John RN Taylor. 2001. Starch properties as affected by sorghum grain chemistry. Journal of the Science of Food and Agriculture 81(2): 245-251.

Beta, T., L.W. Rooney, L.T. Marovatsanga and J.R.N. Taylor. 2001. Effect of chemical treatments on polyphenols and malt quality in sorghum. J. Cereal Sci. (in press).

Beta, T., L. W. Rooney, J.R.N. Taylor. 2000. Effect of chemical conditioning on the milling of high-tannin sorghum. J. Sci. Food Agric 80:2216-2222.

Bugusu, B.A., Campanella, O., Hamaker, B.R. 2001. Improvement of sorghum-wheat composite dough rheological properties and breadmaking quality through zein addition. Cereal Chem. 78:31-35.

Han, X.Z., Hamaker, B.R. 2000. Functional and microstructural aspects of soluble corn starch in pastes and gels. Starch/Staerke 2-3:76-80.

Hugo, L.F., Rooney, L.W., and Taylor, J.R.N. 2000. Malted sorghum as a functional ingredient in composite bread. Cereal Chem. 77(4):428-432.

Books, Book Chapters and Proceedings

Awika, J. M., Rooney, L.W., and Waniska, R.D. 2001. Exploring the potential of sorghum phenols as antioxidants. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference, February 18-20, Nashville, TN, p. 103-107.

Bueso, F., Medina, J., Carrillo, P., Rooney, L.W. and Suhendro, E. 2001. Quality and shelf stability of alkaline cooked products made with food-type sorghums versus corn. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference, February 18-20, Nashville, TN, p. 116-120.

Gordon, L.A., Awika, J., Rooney, L.W., Waniska, R.D. and Suhendro, E.L. 2001. Characteristics of breads baked with sorghum brans high in phenolic compounds. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference, February 18-20, Nashville, TN, p. 98-102.

Lusas, Ed and Rooney, Lloyd W., eds. Snack Foods Processing. 2001. Technomic Publishing Company, Lancaster, PA. 639 pp.

Rooney, L.W. and R.D. Waniska. 2000. Sorghum food and industrial utilization. In C.W. Smith and R.A. Frederiksen (Eds.). Sorghum: Origin, History, Technology, and Production. New York, NY. Pp. 689-729.

Rooney, Lloyd W. 2001. Food sorghums-perspectives and marketing. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference, February 18-20, Nashville, TN.

Rooney, Lloyd W. 2001. Future sorghum food and industrial utilization markets. 4th Australian Sorghum Conference. February 5-8, 2001, p. 40-44.

Rooney, Lloyd W. 2001. White food sorghum technology. US Grains Council, Food Products Development Project and Sorghum Food Products, June 19-21, Tokyo, Japan.

Waniska, R.D. and Rooney, L.W. 2000. Structure and chemistry of the sorghum caryopsis In C.W. Smith and R.A. Frederiksen (Eds.). Sorghum: Origin, History, Technology, and Production. New York, NY. Pp. 649-688.

Waniska, Ralph D., R.T. Venkatesha, A. Chandrashekar, S. Krishnaveni, F.P. Bejosano, J. Jeoung, J. Jayaraj, S. Muthukrishnan and G.H. Liang. 2001. Antifungal proteins and other mechanisms in the control of sorghum stalk rot and grain mold. Global 2000 Conference Proceedings, September 23-30, Guanajuato, Mexico.

Waniska, Ralph D. and Lloyd Rooney. 2000. Sorghum grain for increased utilization. In Global 2000 Conference Proceeding. September 23-30, 2000. Guanajuato, Mexico.

Weaver, C.M., Mason, A.C., Hamaker, B.R. 2000. Food uses, *In* Designing Crops for Added Value, American Society of Agronomy, Madison, WI.

Zelaya, Nolvia, H. Yeggy, E.L. Suhendro and L.W. Rooney. 2001. Characterization of table tortillas from sorghum high in phenolic compounds. Pp. 2-4. In Proceedings of the Tortilla Industry Association Seminar, City of Industry, CA. May 20-23, 2001.

Dissertation and Theses

M.S.

Awika, Joseph. December 2000. Sorghum phenols as antioxidants. M. .S Thesis. Texas A&M University, College Station, Texas. 90 pp.

Mix, N.C. 2000. Origin and role of fragmented starch in couscous and porridge stickiness. M.S. thesis. Purdue University, West Lafayette, IN.

Zelaya, Nolvia. May 2001. Characterization of tortillas and tortilla chips from sorghum varieties high in phenolic compounds. M.S. Thesis. Texas A&M University, College Station, Texas. 129 pp.

Miscellaneous Publications

Rooney, L.W. 2000. Food and nutritional quality of sorghum and millet. Project TAM-226. INTSORMIL Annual Report 2000, University of Nebraska, 54 Nebraska Center, Lincoln, NE 68583, pp. 141-152.

Abstracts

Aboubacar, A. and B.R. Hamaker. 2000. A new turbidity assay rapidly and efficiently identifies highly digestible sorghum cultivars. American Association of Cereal Chemists annual meeting, Kansas City, November, p. 271.

Awika, J.M., L.W. Rooney and R.D. Waniska. 2000. Comparing antioxidant potential of high tannin sorghums with those of common fruits and vegetables. AACC 85th Annual Meeting, http://www.scisoc.org/aacc/ meeting/2000/abstracts /a00ma172.htm, November 5-9, Kansas City, MO.

Bejosano, Feliciano P., William L. Rooney, Robert R. Klein, Lloyd W. Rooney and Ralph D. Waniska. 2001. Antifungal proteins in commercial hybrids and elite sorghums. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference. p. 84, February 18-20, Nashville, TN.

Bugusu, B.A. and B.R. Hamaker. 2000. Effect of added zein on properties and microstructure of sorghum-wheat composite flour dough and bread. American Association of Cereal Chemists annual meeting, Kansas City, November, p. 325.

Gordon, L.A., M. Mitre-Dieste, J. Awika, L.W. Rooney, E.L. Suhendro and R.D. Waniska. 2000. Characteristics of breads baked with sorghum brans high in antioxidants. AACC 85th Annual Meeting, November 5-9, Kansas City, MO.

Huang, C.P. and Hamaker, B.R. 2000. Microstructural study of peripheral cells of developing normal and high protein digestibility mutant sorghum cultivars. American Association of Cereal Chemists annual meeting, Kansas City, November, p. 265.

Mitre-Dieste, C.M., L.A. Gordon, J. Awika, E.L. Suhendro and L.W. Rooney. 2001. Cookies made with sorghum brans high in phenols and catechins. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference, p. 54, February 18-20, Nashville, TN.

Mitre-Dieste, C.M., L.A. Gordon, J. Awika, E.L. Suhendro, and L.W. Rooney. 2000. Cookies made with sorghum brans high in phenols and catechins. AACC 85th Annual Meeting, November 5-9, Kansas City, MO.

Mix, N.C., A. Aboubacar, and B.R. Hamaker. 2000. Origin of a water-soluble carbohydrate fraction related to couscous stickiness. American Association of Cereal Chemists annual meeting, Kansas City, November, p. 282.

Rooney, W.L., L.W. Rooney, D. Pietsch, S.D. Collins. 2001. The tan plant hybrid sorghum test - purpose, use and function. 2001 Sorghum Industry Conference & 22nd Biennial Grain Sorghum Research and Utilization Conference, p. 35-36, February 18-20, Nashville, TN.

Rooney, L.W. 2000. The functionality and properties of new sorghums. AACC 85th Annual Meeting, http://www.scisoc.org/aacc/ meeting/2000/abstracts/ a00ma335.htm. November 5-9, Kansas City, MO.

Zelaya, N., H. Yeggy, E.L. Suhendro, L.W. and Rooney. 2000. Characterization of table tortillas from sorghum high in phenolic compounds. AACC 85th Annual Meeting, November 5-9, Kansas City, MO.

Zelaya, N., H. Yeggy, E.L. Suhendro, L.W. and Rooney. 2000. Characterization of table tortillas from sorghum high in phenolic compounds. AACC 85th Annual Meeting, November 5-9, Kansas City, MO.

Zelaya, N., H. Yeggy, E.L. Suhendro and L.W. Rooney. 2001. Characterization of table tortillas from sorghum high in phenolic compounds. 2001 Sorghum Industry Conference & 22nd Biennial *Grain Sorghum Research and Utilization Conference*, p. 55, February 18-20, Nashville, TN.

Zhang, G. and B.R. Hamaker. 2000. Detection of a three-component complex among starch, protein, and free fatty acid. American Association of Cereal Chemists annual meeting, Kansas City, November, p. 314.

INTSORMIL's collaborative research with scientists of the Institut d' Economie Rurale (IER) in Mali began in 1981. During the past twenty years, the research skills of many scientists in Mali have been strengthened through the Collaborative Research Support Programs, and particularly by the INTSORMIL CRSP. In a food science laboratory of IER, it's time to celebrate the success of 100% sorghum biscuits formulated by IER food scientists, using flour of the white, guinea-type N'Tenimissa sorghum variety developed by the collaboration of IER sorghum breeders and American scientists in INTSORMIL's collaborative research program. Left to right: Dr. Mamourou Diourté, plant pathologist; Mme Berthé Aissata Bengaly, food technologist; Mr. Bocar Sidibé, assistant sorghum breeder; Dr. John Leslie, plant pathologist, Kansas State University; and Dr. Aboubacar Touré, sorghum breeder and Head of Mali's National Sorghum Program.