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Introduction and Program Review

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Administration and Management

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

Education

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

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

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

Networking

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

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

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

Regional Activities and Benefits

West Africa

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

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

Horn of Africa

(Ethiopia, Eritrea, Kenya, Tanzania, Uganda)

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

Southern Africa

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

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

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

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

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

Central America (El Salvador, Nicaragua, Honduras)

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

Future Directions

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

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

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

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

