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INTSORMIL

1997 Annual Report

Executive Summary

Fighting Hunger 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

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Kansas State University
Mississippi State University
University of Nebraska
Purdue University
Texas A&M University

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Introduction and Program Overview

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 The CRSPs are communities of U S Land Grant Universities working with USAID and USAID Missions, other U S Federal Agencies, developing country National Agricultural Research Systems (NARS), developing Country Colleges and Universities, International Agricultural Research Centers (IARCs), private agencies, industry, and private voluntary organizations (PVOs) The Sorghum and Millet Collaborative Research Support Program (CRSP) is one of nine CRSPs currently in operation

Agricultural scientists of the Sorghum and Millet Collaborative Research Support Program (INTSORMIL CRSP), or simply INTSORMIL conduct collaborative research using partnerships between U S University scientists and scientists of the National Agricultural Research Systems (i e , NARS) INTSORMIL is programmatically organized for efficient and effective operation and includes most of the public sorghum and millet research expertise 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 U S and LDC agriculture*** Collaborating NARS and U S scientists jointly plan and execute research that mutually benefits developing countries and the United States The Global program of INTSORMIL is maintained in the agroecological zones of western southern and eastern Africa, and in Central America These sites support the general goals of building NARS institutional capabilities, creating human and technological capital for solving sorghum and millet constraints with sustainable global impact promoting economic growth, enhancing food security and encouraging entrepreneurial activities The universities which are active in the INTSORMIL CRSP are Kansas State University Mississippi State University, University of Nebraska Purdue University and Texas A&M University

Sorghum and millet are important food crops in moisture stressed regions of the world They are staple crops for millions in Africa and Asia which, in their area of adaptation cannot be reliably substituted by other cereals The development of food sorghums and sorghums with improved feeding properties such as increased digestion and reduced tannin content has contributed to sorghum becoming a major feed grain in the U S , countries in Central and South America, and in Africa Pearl millet is becoming an important feed source in poultry feeds in the southeastern U S The new food sorghums produce grain that can be used for special ethnic and dietary products as well as for traditional food products Special white sorghums in Mali have the potential for allowing farmers' wives to process sorghum into high-value food products for sale in village and urban markets which can compete with wheat and rice products The traditional types of sorghums cannot make effective food products that can compete with wheat and rice products Pearl millet also has great potential for processing into high-value food products which can be sold in village and urban markets that can compete with wheat and rice products These developments have occurred because of the significant interaction that INTSORMIL scientists U S and Host Country, have in conducting research from grain production through processing and marketing

Although significant advances have been made in improvement and production of sorghum and millet in the regions which INTSORMIL serves, population continues to exceed production capacity There remains an urgent need to continue the momentum of our successes in crop improvement as well as our efforts in strengthening the NARS

INTSORMIL continues to maintain 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 promotes educational outcomes in collaborating host countries The outcomes include institutional strengthening development of collaborative research networks promoting and linking to technology transfer and dissemination, infrastructure development, and enhancing national, regional, and global communication linkages ***A major innovative aspect of the INTSORMIL focus is to maintain continuing relationships with collaborating host country scientists 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 regional networks in which they collaborate***

Conserving biodiversity and natural resources Research outcomes 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 enlarge the range of agricultural and environmental choices Thus, INTSORMIL promotes conserving millet and sorghum germplasm, conserving natural control of sorghum and millet arthropod pests and diseases, developing resource-efficient cropping systems developing integrated pest management programs, 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 eco-geographical regional sites have been strengthened by using U S and NARS multi-disciplinary research teams focused on common objectives and unified plans INTSORMIL scientists provide global leadership in biotechnology research on sorghum and millets The output from these disciplinary areas of research are linked to immediate results Biotechnology and other tools of science integrated with traditional science will contribute to alleviating production and utilization constraints in sorghum and pearl millet within the medium term of 5 to 10 years New technologies are then extended to farmers' fields in developing countries and the United States through further collaborative efforts In addition, INTSORMIL plays a part in initiating consideration of economic policy and processing constraints to regaining the competitiveness of sorghum and millet as a basic food staple

Supporting information networking INTSORMIL research emphasizes working with existing sorghum and millet networks to promote effective technology transfer from prime sites to local and regional institutions Technology transfer is strengthened by continued links with regional networks, International Agricultural Research Centers, and similar local and regional institutions Emphasis is placed on strong linkages with extension services, agricultural production systems, private and public seed programs, agricultural products supply businesses, and non-profit 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

Promoting demand driven processes Development of economic analysis for prioritization of research and farm-level industry evaluation, development of sustainable food technology, processing and marketing systems, are all 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 and pearl millet for food Research products transferred to the farm will seek to spur rural economic growth and provide direct economic benefits to consumers INTSORMIL researchers assess consumption shifts and socioeconomic policies intended to reduce effects of price collapses and address methods for reducing processing for sorghum and millet Research is aimed at reducing effects of price collapse in high-yield years and creating new income opportunities INTSORMIL socioeconomic projects measure impact and diffusion of sorghum and pearl millet technologies 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 both the U S and the developing world, especially the semiarid tropics There is international recognition by the world donor community that the developing country agricultural research systems must assume ownership of their development problems and move toward achieving resolution of them The 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 and presents a win win situation for international agricultural development

Administration and Management

The University of Nebraska at Lincoln (UNL) provides 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 identified in the overall research plan of the program Country project funds, managed by the ME and U S participating institutions support collaborative research to the benefit of both the U S and country programs 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 host country coordination, budget management, and review

Several major decisions and accomplishments were made by the ME, BOD, and TC during the past year

- The TC BOD and ME institution interviewed and selected a candidate who was hired by the ME for the Associate Program Director position within INTSORMIL
- The TC and the ME finalized the RFP for a new project on Sorghum/Millet Marketing Economics
- The BOD approved a budgeting process developed by the TC This involves the TC considering PI workplans, PI budgets, PI previous annual report discipline budget recommendation and the TC discipline representatives justification for budget recommendations A project evaluation form has been developed for testing
- The BOD of Directors approved the EEP Rotation schedule for the period of 1998-2002

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

- INTSORMIL CRSP Directory update, INTSORMIL Publication, July, 1996
- INTSORMIL Annual Report 1996, INTSORMIL Publication No 96-1
- INTSORMIL Annual Report 1995, Executive Summary, INTSORMIL Publication No 96-2

The 1996-97 Technical Committee (TC) was elected The TC members are Dr Stephen Mason, University of Nebraska, Dr George Teetes, Texas A&M University, Dr Lloyd Rooney, Texas A&M University, Dr Darrell Rosenow, Texas A&M University, Professor David Andrews, University of Nebraska, Dr Gary Peterson, Texas A&M University, Dr Aboubacar Toure, IER/Mali and Dr Francisco Gomez, EAP/Honduras

The announcement for the International Conference on Genetic Improvement of Sorghum and Pearl Millet, in Lubbock, TX, September 23-27, 1996 was distributed worldwide INTSORMIL and ICRISAT were the co-sponsors for this event with contributions from the Rockefeller Foundation, the Overseas Development Administration (ODA), the National Grain Sorghum Producers Association, the Texas Seed Trade Association, Texas Tech University and Texas A&M University There were 248 persons who participated in the conference from 38 countries

INTSORMIL partnered with the Bean/Cowpea CRSP and World Vision International for a project on technology transfer in West Africa under the West Africa NRM InterCRSP project managed by the IPM CRSP on behalf of the CRSP Council This project was initiated during this year

INTSORMIL signed MOUs with the Kenya Agricultural Research Institute (KARI), the Uganda National Agricultural Research Organization (NARO) and the Division of Agricultural Research and Extension (DARES), Eritrea during the 1996-97 time frame

Training

Training of host country scientists contributes to the capability of each host country research program to stay abreast of environmental and ecological changes which alter the balance of sustainable production systems The strengthening of host country research institutions contributes to their capability to predict and be prepared to combat environmental and ecological changes which affect production and utilization of sorghum and pearl millet A well balanced institution will have to be prepared to prioritize and blend its operational efforts to accomplish the task of conserving and efficiently utilizing its natural resources To this end training is an extremely critical component of development assistance

During 1996-97, there were 56 students from 21 different countries enrolled in an INTSORMIL advanced degree program and advised by an INTSORMIL principal investigator Approximately 80% of these students came from countries other than the U S , which illustrates the emphasis placed on host country institutional development INTSORMIL also places importance on training women which is reflected in the fact that 16% of all INTSORMIL graduate students were women

The number of students receiving 100% funding by INTSORMIL in 1996-97 totaled 18 An additional 21 students received partial funding from INTSORMIL The remaining 17 students were funded from other sources but are working on INTSORMIL projects The number of students receiving 100% funding from INTSORMIL has dropped from a high of 71 in 1986 down to a low of 17 in 1993-94 This is, in part, due to training taking place under other funding sources, but an even more significant factor is that budget flexibility for supporting training under INTSORMIL projects has been greatly diminished due to reductions in our overall program budget and because of inflationary pressures

In addition to graduate degree programs, short-term training programs have been designed and implemented on a case-by-case basis to suit the needs of host country scientists Several host country scientists were provided the opportunity to upgrade their skills in this fashion during 1996-97

Networking

The Sorghum/Millet CRSP Global Plan for Collaborative Research includes workshops and other networking activities such as research 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 ASARECA, ROCARS SADC and others) private industry and government extension programs to coordinate research and technology transfer efforts

Supports 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, SADC/ICRISAT, SMIP, SAFGRAD, ICRISAT Sahelian Center, ICRISAT West Africa Sorghum Improvement Program, ROCAFREMI, EARSAM of ICRISAT, ICRISAT/Mexico CIAT and CLAIS of Central and South America There has been excellent collaboration with each of these programs in cosponsoring 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 and the ROCAFREMI (Reseau Ouest et Centre Africain de Recherche sur le Mil, Niger) of West/Central Africa Sudanese collaborators have provided leadership to the Pan African *Striga* Control Network INTSORMIL plans to strengthen linkages among the NARS with which it collaborates, as well as international and regional organizations and networks INTSORMIL will continue to promote free exchange of germplasm, technical information, improved technology, and research techniques

Benefits to Host Countries

Realized Benefits of Program

INTSORMIL can document a wide range of benefits to host countries U S agriculture, and the broader scientific community Many of these benefits have reached fruition with improved programs, economic benefits to producers and consumers, and maintenance or 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 have built positive long-term relationships between scientists, citizens and governments of host 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 sorghum and pearl millet production in developing countries and in the United States in sustainable ways

International

Scientific by Technical Thrust

Germplasm Enhancement and Conservation

Germplasm exchange movement of seeds in both directions between the U S and host countries has involved populations, cultivars, and breeding lines carrying genes for resistance to insects, diseases, *Striga*, drought and soil acidity, as well as 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 host country use include the following

* Improved yield (for all host 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 host countries)
* Improved grain quality characteristics for food and industrial uses (for all host countries)

The hybrid sorghum success story in Sudan traces to ICRISAT/INTSORMIL/ARC collaboration in which they developed produced seed and popularized the first hybrid sorghum Hageen Dura-1 (Tx623 × K1567), for this country The female line Tx623 was used due to its wide adaptation high yield potential and drought resistance It currently is produced on about 12% of the sorghum area in the Sudan Gezira Irrigation Scheme, the largest in the world under one management Impact studies show that the internal rates of return to this research without further extension of the production area in Hageen Dura-1 were 23% for low fertilizer levels and 31% for high fertilizer use levels With the present rate of diffusion, the investment on this research would pay approximately $1 million of annual benefits

The Central America/Honduras sorghum program is improving sorghum research and production throughout the region through research training, and outreach activities Research based in Honduras is extended throughout the region in both the maicillo criollo enhancement program and hybrid performance testing Small-scale hillside producers benefit through the maicillo criollo enhancement while larger producers through the hybrid performance test The hybrid performance test allows commercial industry and producers access to unbiased yield data and comparison of hybrids in the region Central America is the only location in the world where sorghum has evolved to fit the cropping systems of the steepland hillsides Collaboration with projects such as LUPE (Land Use Productivity Enhancement) allows hillside producers to see the benefits of a total management package for improved sorghum production The INTSORMIL/Honduras sorghum project has assumed the responsibility for conserving this sorghum gene pool The goal of the conservation effort is to create a mosaic of maicillo enhanced maicillo and improved variety fields in which genes flow freely among these different kinds of sorghum Ostensibly, an informal network of village level land race custodians will care for this germplasm as they have cared for maicillo The creation of enhanced maicillo cultivars and their subsequent deployment on-farm, is not only intended to increase genetic diversity in situ, but to stave off replacement of maicillos by introduced cultivars There are four improved dwarf maicillo varieties ready for release which will stabilize sorghum production through stress resistance and excellent quality grain characteristics

In Central America sorghum utilization patterns are shifting as the demand for poultry rapidly increases (8 4% annually in Honduras) For the time period of 1990-1993 sorghum production in Central America grew 18 percent at a rate of 4 42% per year In 1994, seventy six percent of the sorghum was utilized for animal consumption and 17% for human consumption in Honduras For human consumption 6% was for on-farm use and the other 11% was sold With the rapid expansion of poultry feeding, sorghum has been filling much of the increased demand for feed grains Of the cereal component in Honduran commercial feeds, sorghum increased its share from 4% in 1985 to 26% in 1993 All over Central America there has been a rapid growth of hybrid sorghum seed sales for use in production of sorghum grain for feed It is estimated that 35% of the sorghum area was planted to hybrids in 1995 Sorghum is successfully replacing maize in animal feed and releasing an equivalent amount of white maize for human consumption

The principal objective of an impact assessment activity completed in July, 1996 was to measure the impact of the new cultivars and associated technologies developed in the SRN/EAP/INTSORMIL program in Honduras Secondly, the assessment team looked at the impacts and production systems in other principal sorghum producing countries in the region, El Salvador and Nicaragua The primary research output in all three countries was the selection of new higher yielding white seeded varieties of sorghum Conclusions reached from this impact assessment of the Sorghum/Millet CRSP research in Central America indicate that benefits from the varietal research in the three countries ranged from $437,000 per year in Nicaragua, $600 000 in Honduras (low side estimate), to $1 900 000 per year in El Salvador The two new cultivars introduced in El Salvador were introduced with more extension and public policy support for improved seed production and credit Estimates include only the benefits accruing from the adoption of cultivars developed by the public research systems Note that only the Honduras benefits can be totally credited to the SRN/EAP/INTSORMIL program In Honduras improvements in the quality and availability of seed of varieties will continue to be critical for small- and medium-scale farmers

Researchers of the INTSORMIL CRSP have developed a new drought tolerant sorghum hybrid designated NAD-1 (NAD-1 = Tx623 × MR732) has proven to be highly productive and well adapted in Niger The grain quality is acceptable for local food preparations and the yields reported from 100 on-farm demonstration plots in 1992 were approximately twice the yields of local varieties Overall, the average yield of NAD-1 between 1986 and 1994 is 2758 kg ha^{1} on-station, ten times the average yield of the farmer in Niger (273 kg ha^{1}) In 1993 the farm level plots showed the average farmer yield for the Konni and Jirataoua region was 2365 kg ha^{1} for NAD-1 In 1994 NAD-1 yielded an estimated 1725 kg ha^{1} (Say), 3500 kg ha^{1} (Jirataoua) 3800 kg ha^{1} (Cerasa), and 4600 kg ha^{1} (Konni) for an overall farmer yield of more than 3000 kg ha^{1} This is compared to the national average of 273 kg ha^{1} In 1995 farmer demonstration trials were conducted in an area extending from Konni to Zinder eastward and as far north as Dakora The 1995 trials compared the NAD-1 hybrid yields to one of the best local landraces, Mota Maradi (MM) The objectives were to check the extent of NAD-1 superiority over locals under as diverse conditions as possible with farmer management, and assess its area of best performance A preliminary yield analysis showed that, overall, NAD-1 yielded an average of 1 6 t ha^{1} compared to 1 1 t ha^{1} for MM This is about 50% better yield for the hybrid This is especially important because 1995 was not a good year Farmer interest has been very high Head size and grain yield have been impressive This is the first sorghum hybrid that has actually reached farmer fields in Niger In early 1996, a seed program consultancy sponsored by INTSORMIL was put into place The draft report indicates that the hybrid NAD-1 and the country of Niger fulfill three basic requirements for the establishment of a seed industry, i e, (1) it is important that a cultivar be identified that has significant yield, good grain quality and is not more susceptible to pests than local varieties (2) the area in the country should be large enough to support a seed industry, and this exists in Niger (area sown to sorghum is in excess of one million hectares) and (3) the cultivar involved should be a hybrid in order to permit the establishment of a suitable market and the hybrid should be readily producible Results of Regional Trials indicate a wide adaptation of NAD-1 in other countries of the region, indicating the opportunity for an international market The experience of developing a private seed industry in Niger would be immediately valuable to other countries of the region with the production and marketing of hybrid seeds as they realize superior hybrids from their research

Through the integrated cooperation of sorghum breeders and food scientists we now understand many of the factors necessary to improve the nutritional value of sorghum locally processed in villages Sorghum flour is less digestible than most cereal flours unless it is processed using local village procedures which have evolved over hundreds of years We now understand the scientific reasons why processing is important This knowledge will help modify and improve the traditional processing methods and to develop improved processing methods for utilization in other countries in the world where sorghum is used as a feed for food grain The 1996 annual report noted for the first time that a genetic solution may be possible for the digestibility problem In 1996-97 Dr Bruce Hamaker, INTSORMIL scientist in the Food Science Department at Purdue University identified modified sorghum lines with a high protein digestibility trait that have good fill of vitreous endosperm and improved milling characteristics compared to softer grains

The INTSORMIL goal for the parasitic weed, *Striga*, is to exploit the unique life cycle and parasitic traits of *Striga*, especially the chemical signals required for germination, differentiation, and establishment The genetic inheritance the low production of the *Striga* germination stimulant in SRN39 has been identified The low production of the ger mination stimulant in this line is inherited as a single nuclear, recessive gene which is largely additive INTSORMIL project PRF-213 also has reported on the development of an in vitro assay for post-infection *Striga* resistance This assay will allow for identification of genetic variants that discourage infection of *Striga* as a hypersensitive reaction where penetration is followed by necrosis, or slowed development of the parasite after penetration as well as incompatibility resulting in stunted growth or eventual death of the parasite It was reported in 1996 that eight tons, one ton each of eight high-yielding *Striga*-resistant food grain sorghum varieties were released by Purdue University to the PVO, World Vision, for use in nine countries in Africa During the first eleven months of operation, these *Striga*-resistant food quality sorghums have been tested on field stations or in farmers fields, or both, in the following countries Ghana, Senegal, Mali, Niger Sudan, Rwanda, Mozambique, and Eritrea The Ethiopian Sorghum Improvement Program has selected two of the eight varieties for large scale seed multiplication and dissemination in 1998

Excellent progress has been made in Mali to develop white-seeded, tan-plant guinea cultivars Emphasis is being placed on intercrosses using the experimental guinea-type white-seeded, tan-plant cultivar named N'tenimissa (Bimbiri Soumale × 87CZ-Zerazera) with elite local guineas and with other high-yielding non-guinea breeding lines which lack the necessary head bug tolerance They have good guinea plant, grain, glume, and panicle characteristics, and some have juicy stems Two new lines were selected in 1995 for on-farm testing in the rainy season of 1996 Grain of N'tenimissa will be increased on about five ha in 1996 for use in utilization and value-added product development The PVO, World Vision, distributed N'tenimissa and *Striga* resistant cultivars in 20 on-farm trials in 1996-97 In Northern Mali, CARE is cooperating with IER and testing new sorghum cultivars at about 20 sites World Neighbors has provided improved cultivars of millet and sorghum with a package of improved production technologies to more than 20 communities in the Segou area of Mali

In Mali, lines developed by Dr Bretoudeau at the Agricultural School at Katiabougou and evaluated in a 32-line Advanced Early Test produced the highest yield These lines have good grain milling qualities and will be evaluated in the IER Food Quality Laboratory

Sustainable Production Systems

In agronomy and soil/crop management, a major INTSORMIL impact has been understanding the soil/cropping system/genotype interactions Research in Niger has shown small and large production practice differences on pearl millet grain yield production dry matter accumulation, and nutrient uptake Research results support recently published recommendations of 20 000 hills/ha, 40 kg ha $^{-1}$ nitrogen and 18 kg ha $^{-1}$ phosphorus for optimizing pearl millet grain yield , even in dry years In Mali, research indicates pearl millet/cowpea rotations resulted in the highest grain yield, stover nitrogen concentration and agronomic use efficiency of nitrogen INTSORMIL research results have demonstrated 18 to 203% yield enhancement of pearl millet and grain sorghum yields in Africa by use of crop rotation with legumes, and a 20 to 50 kg ha $^{-1}$ N equivalent contribution to cereals following legumes In Mali and Niger, intercropping has shown land use efficiency increases of 14 to 48% over sole crops and also enhanced yields of succeeding crops when intercrop legume yields are high Obviously legume production no matter the system is important to producing optimal sorghum and pearl millet yields when N fertilizer is limiting, especially for improved cultivars Crop residue treatments had no effect on grain yield, but residues left on the surface had greater soil phosphorus and potassium levels than with residue removal or incorporation after five years Cropping increased soil pH and carbon, but decreased potassium and cation exchange capacity INTSORMIL has supported IER scientists who have worked in cooperation with the PVO World Neighbors and the Malien Extension Service(PNVA) over the past five years to extend technologies developed by IER World Neighbors workers report wide adoption of early-season grain sorghum and pearl millet cultivars, improved intercropping practices, and improved manure management through animal corralling and composting with crop residues

Sustainable Plant Protection Systems

In crop protection a wide range of sources of resistance to 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*

Several *Striga* resistant lines from Purdue University, evaluated in Mali showed good *Striga* resistance, but had inferior grain quality compared to local cultivars Work is continuing to improve the grain quality of these lines

F_3 progeny of the cross (Malisor 84-7 * #-34) for molecular marker analysis of head bug resistance showed excellent differentiation for head bug damage Nine new sorghum breeding progeny showed head bug resistance equal to that of Malisor 84-7 Observations indicate that head bug infestations in on-farm trials is much lower than in experiment station nurseries This means that sorghum with somewhat lower levels of head bug resistance may well work at the farm level, even though they may show significant damage under certain Station conditions

Sorghum lines resistant to sugarcane aphid have been identified in Botswana and Zimbabwe, and the mechanism of resistance has been assessed Genes for resistance have been identified, confirmed, and initially utilized Efforts are now being made to move the resistance genes into parental lines which are used in hybrid combinations for combine height, early maturing genotypes with acceptable agronomic traits

In Mali, efforts are being continued toward the establishment of a National Sorghum and Millet Disease program This includes evaluation of INTSORMIL nurseries for reaction to the prevalent pathogens in Mali INTSORMIL pathologists (NARS and U S) are collaborating with program entomologists to study the interaction of head mold and insects (head bug) on grain deterioration in the field

The INRAN/INTSORMIL pathologist from Niger is in long term training at Texas A&M University He is conduct ing field trials and laboratory experiments on acremonium wilt of sorghum This research is part of the work for the Ph D degree Field trials were conducted at the Konni Research Station and in farmers fields His research focuses on the association between nematodes and acremonium wilt

In Honduras, ergot appeared and data was obtained on the level of disease in selected nurseries and collateral hosts Similarly, INTSORMIL scientists helped organize meetings on ergot in Brazil in collaboration with ICRISAT and in collaboration with the National Grain Sorghum Producers in Amarillo TX The advent and rapid spread of ergot forced INTSORMIL scientists to focus on the problems of management of this disease As of June 30 1997, the disease had spread throughout southern Texas and as far north as Victoria and west to the San Antonio area The DNA fingerprinting of head smut isolates from maize and sorghum indicate that differences among these fungi are much greater than those within suggesting parallel evolutionary development

Pearl millet head miner (*Heliocheilus albipunctella*) or MHM is a serious insect pest of West Africa and infestation sometimes approaches 95% with a collective grain loss of 60% MHM has been found to be an excellent candidate for control strategies emphasizing effective natural enemies i e , biological control MHM supports a relatively large guild of natural enemies, it occupies a predictable habitat in an ecosystem with relatively consistent annual presence and has one generation per year Two major predators and two commonly encountered parasites have been identified and are being studied During 1995/1996, two NARS scientists from West Africa were admitted as graduate students in the Department of Entomology at Texas A&M University In 1996-97 they began their graduate degree research at the ICRISAT Sahelian Center Their research objectives and results will build on findings for MHM biological control reported by INTSORMIL scientists in 1994, 1995 and 1996 Annual reports When this research is complete, the key mortality sources, including natural enemies of MHM, will be identified and methods of manipulation will be described for those that can be effectively managed for optimal mortality to MHM populations The INTSORMIL MHM researchers continue to work closely with other pearl millet scientists of the West Africa ROCAFREMI millet network INTSORMIL participated in the three ROCAFREMI network meetings during this program year

A bacterial disease of pearl millet first observed in Southern Zimbabwe in 1995 and tentatively identified as *Pseudomonas syringae* by D Frederiksen at the University of Zimbabwe was later identified as *Pantoea agglomerans* by D Frederickson Several sorghum disease nurseries, other nurseries, selected sorghums, and advanced generation breeding germplasm developed or introduced in conjunction with INTSORMIL collaborators were evaluated at Sebele Botswana Cultivars with good sugarcane aphid resistance and good agronomic characteristics were identified and identified for further evaluation

In Central America, sorghum and maize are damaged each year by soil-inhabiting insects stem borers and panicle-feeding insects that contribute to reduced yields of both crops on subsistence farms in Honduras, as well as in other countries in Central America, however the major insect pest constraint to these crops is foliage feeding insects The pest complex has been identified by INTSORMIL project MSU-205 to consist principally of three armyworm species and a grass looper Insect pest management tactics have been investigated as independent control practices on subsistence farms in southern Honduras Recommendations for planting dates weed control and insecticide applications to manage the lepidopterous defoliators have been developed This information will assist subsistence farmers in Honduras and surrounding countries with similar insect constraints in producing grain crops with increase yield with minimum cost for pest control with reduced risk to human health

Crop Utilization and Marketing

Many quality and utilization studies were done in the food quality laboratory in Sotuba Mali including evaluation of grain from yield trials In general the local guinea type cultivars and checks and the Bretaudeau mutation derived, true guinea lines of Dr Bretaudeau had the best quality, based on decortication yield and grain hardness In laboratory-scale studies with GAM (Generale Alimentaire du Mali, the major bread and cookie producer in Bamako) cookies made with 5% and 10% N tenimissa flour (substituted for flour from imported wheat) were good quality taste and texture Bread made by GAM with 5-10% sorghum flour was acceptable and was preferred by consumers over a wheat/corn flour mix There was some concern about black specks in the flour from the N'tenimissa grain produced under open pollination conditions The major constraint to increased utilization of the flour from white, tan-plant sorghums in various products is the lack of a consistent supply of good quality grain This will require some consistent, sizeable production and a system to preserve the identity of that grain in marketing and processing "Crunch" was made from sorghum, and the varieties of Wassoulou and Lakaheri produced superior crunch compared to N'tenimissa Some womens associations and small entrepreneurs are processing crunch for local markets

The Cereal Quality Laboratory (LQC) at INRAN in Niger has conducted several surveys to determine the effect of crop selection and pearl millet varieties on couscous preparation in Niger Sorghum, pearl millet, and durum wheat all produced acceptable couscous in this study Work continues with INRAN/Niger scientists on sorghum and millet-based couscous The processing unit consists of a decorticator/mill, agglomerator/siever (designed by CIRAD, France), steamer, solar drier, and packaging sealer This equipment is being used for research purposes, and also as a demonstration and testing unit to encourage local entrepreneurs to commercialize millet or sorghum couscous A commercial-type product will also be tested in the market place Cultivars of sorghum and millet have been identified that make good quality couscous Initial efforts have been made to bring in entrepreneurs to use the unit and then to market test the couscous resulting from those efforts

Benefits to the U S

Germplasm Enhancement and Conservation

INTSORMIL PIs have developed numerous germplasm lines resistant to biotype C, E, and/or I biotype greenbug which have been distributed to private seed companies for use in their breeding programs Gene mapping has shown that genes conferring resistance to different greenbug biotypes are slightly different, but probably control the same resistance process Genetic markers co-segregating for greenbug resistance in sorghum were detected on four separate linkage groups Two genetic markers are linked to greenbug biotype C resistance, three to biotype E two to biotype I and one to biotype K resistance Efforts to assess the genetic diversity among populations of greenbug have been initiated as companion research to the plant biotechnology research Agronomically viable greenbug biotype I parental lines were selected for release

INTSORMIL research has confirmed that sorghum midge abundance the subsequent year is reduced when sorghum residue containing overwintering larvae is shredded, disked, and deep plowed after harvest, compared to when residue is only shredded or shredded and disked Sorghum midge resistance in sorghum is caused by early (during day) flowering spikelets with glumes that tightly close before ovipositing sorghum midges are in the field Germplasm resistant to sorghum midge, developed through INTSORMIL support, has served as the foundation for many similar breeding programs throughout the world Three female (male sterile) sorghum midge-resistant parental lines were released to commercial seed companies Seven sets of the lines were distributed under a pre-release memorandum to private seed companies (six U S and one Guatemalan) for evaluation in 1997 Hybrid seed has been distributed to commercial seed companies and extension personnel to evaluate hybrid performance in a large range of environments with or without sorghum midge present These will be the first sorghum midge resistant A/B pairs with the traits needed to produce commercially acceptable resistant hybrids

Materials from the INTSORMIL/USDA/Texas A&M University Sorghum Conversion Program and selected breeding cultivars from other projects are evaluated regularly for resistance to internationally important diseases and insects in a cooperative/collaborative program throughout the sorghum growing world The conversion program consists of substituting a recessive maturity gene for a dominant one and either two or three recessive height genes for dominant ones Backcrossing is done until the short, photoperiod converted line looks like the tropical line when grown in the tropics except for being shorter This allows introducing exotic germplasm from the tropics with potentially desirable characteristics for utilization in the temperate regions of the world Forty fully converted exotic lines and 50 partially converted bulks from the conversion program were released in 1996 The male sterile (A-line) of five new female parental lines were distributed to private companies through a pre-release materials transfer agreement Several additional A-B pairs and R lines were selected for release as germplasm stocks These lines contain various desirable traits, including resistance to downy mildew, head smut, grain mold/weathering, anthracnose charcoal rot both pre- and post flowering drought resistance, food type grain quality and lodging resistance

In January 1995 INTSORMIL/Purdue University reported a breakthrough in sorghum digestibility research Irregularly shaped protein bodies discovered in sorghum kernels under the electron microscope may signal improved human nutrition in some developing countries and higher quality livestock/poultry feed worldwide In 1996-97 new lines were identified with improved grain quality where vitreous central portion of the grain was more filled out Milling and food qualities of the modified vitreous-core sorghum lines with the high protein digestibility trait are being examined

INTSORMIL project UNL-218 released three sorghum seed parents in the U S for private sector use and eight more are being prepared for release Three pearl millet seed parents and three restorer parents are also being prepared for release

Sustainable Production Systems

Studies to develop an agronomic production practices package for dwarf pearl millet as a new alternate crop for the U S have been initiated Narrow row spacing, nitrogen application, and good weed control were identified as important practices Western Nebraska has lower rainfall and a shorter growing season than Eastern Nebraska In Western Nebraska, pearl millet yielded less than grain sorghum at early planting dates, but more at later planting dates Early planting increased pearl millet yield 10 to 15% and grain sorghum by 72% Narrow row spacing produced higher yields for both crops, but the increase of 26% for grain sorghum was much greater than for pearl millet with 6-10% increase In Eastern Nebraska planting date had a small effect on grain yield of both crops across very different years environmentally and soil types Narrowing rows increased yields of both crops, but less than in Western Nebraska

Sustainable Plant Protection Systems

Disease evaluation studies are conducted primarily in large research nurseries in South Texas Several uniform nurseries are grown in locations where sorghum/millet diseases are important These include the International Sorghum Anthracnose Virulence Nursery (ISAVN) in collaboration with ICRISAT, the Uniform Head Smut Nursery (UHSN), the Sorghum Downy Mildew Virulence Nursery (SDMVN), the International Virus Nursery (ISVN), and also a uniform nursery for grain mold (GWT) Growing of these nurseries permits a quick evaluation of pathotype differences among locations and the severity of the problem INTSORMIL also evaluates and distributes elite sorghums in nurseries for evaluation of the multiple resistance of sorghum These are international nurseries and represent a means of distributing elite germplasm from different breeding programs in INTSORMIL

INTSORMIL researchers have developed a dot immunobinding assay (DIA) to distinguish different bacterial pathogens of sorghum and millet The test is easy to perform inexpensive requires limited equipment and chemicals, and was designed with LDC laboratory conditions in mind It has been shown that the causal agent of bacterial leaf streak is seedborne and can remain viable in the seed for more than two years

International collaborative research programs with NARS and ICRISAT scientists have resulted in the development of sustainable insect management strategies and identification of sorghums resistant to sorghum midge, greenbug (biotypes C, E, and I), African sorghum head bugs sugarcane aphid and yellow sugarcane aphid Mechanisms and inheritance of resistance have been determined, and genes conferring resistance have been introgressed into elite parental lines that have been evaluated alone and in hybrid combinations Levels of resistance have been quantified, and economic injury levels established for most of them INTSORMIL research has employed a holistic approach to identify, evaluate, and deploy sorghum midge, greenbug, and yellow sugarcane aphid resistant sorghums as a component of IPM, and to develop and validate sorghum plant and sorghum midge dynamics computer models

Significant advances were made in developing the technology to allow farmers to manage sorghum insect pests Significant advances have been made in biological control and these advances contribute to improved IPM of sorghum and millet, and to improved concepts for using biological control in annual crops For aphids attacking sorghum in the U S predators were demonstrated as key natural enemies for effective biological control of these pests In the U S , phytoseiid predators have been demonstrated as an effective alternative to pesticides for control of spider mites and parasites and were shown to be effective on the American sugarcane borer attacking sorghum In 1996-97 a survey was conducted to assess the extent of use of IPM by sorghum growers in Texas These data will be valuable in determining research and educational efforts needed to increase IPM use by sorghum growers and document the extent of IPM use in sorghum in compliance with governmental goals of having IPM approach used on at least 75% of all crop acres

The impact of insect-resistant germplasm in sorghum production of the U S has been dramatic For example, insecticide use on sorghum in Texas was at an all-time high at the initiation of this CRSP In 1978 nearly 60% of the sorghum acreage in Texas was treated with insecticide while in 1990 only about 24% of the acreage was treated The savings gained from not using insecticide were $6 000,000 per year, and this does not consider the ecological or environmental benefits, or benefits from reduction in insect pest resurgence or secondary pest outbreaks During this project the economic benefit to Texas farmers has been at least $90 000,000

Crop Utilization and Marketing

INTSORMIL scientists originally addressed the tannins as antinutritional factors They developed methods now widely used by others for assaying and characterizing these materials They also developed a simple method to detoxify and improve the nutritional value of high tannin sorghum grain They are elucidating the biochemical mechanisms by which tannins exert their antinutritional effects They are also characterizing the role of tannins and related materials in resistance to birds molds, and leaf diseases Methods for polyphenol analysis, purification and characterization have been widely adopted and used by nutritionists and ecologists studying tannins in other crops and range plants

The most significant finding of late concerns the poor protein digestibility of sorghum In screening 25 selected sorghum genotypes for in vitro protein digestibility they found a range from 66 to 88% for uncooked values and 48 to 81% for cooked values Two sorghum lines had notably higher digestibilities compared to the other sorghums tested Perhaps more important, digestibility of these two sorghums did not decrease appreciably on cooking, which is commonly seen with sorghum This was verified using two in vitro enzyme systems Chemical studies showed that in the two highly digestible sorghums the major storage protein (about 65% of total protein), α-kafirin, was digested much earlier than the other sorghum samples Also, a group of high molecular-weight-proteins, that usually restrict the digestion of α-kafirin, was digested very rapidly This group of sorghums is now being grown to determine if this is a heritable trait If this proves to be so we believe that a rapid screening assay for digestibility can be developed based on chemical differences between genotypes New lines have been identified with improved grain quality and superior protein digestibility Work will continue on development of a rapid screening assay

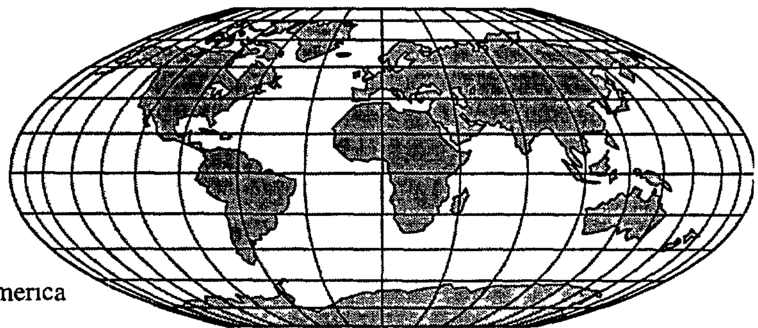
The chemistry, composition structure and nutritional value of sorghum kernels has been related to genes that control pericarp thickness and color and the presence and absence of a pigmented testa From this knowledge, several white, tan plant sorghum inbreds have been released to the seed industry and are being grown in the United States These food hybrids have improved quality for use in livestock feed as well as ingredients in food systems The food hybrids are also in high demand in the export market

The structure and processing properties of pearl millet have been evaluated A white pearl millet grain had excellent acceptance when cooked like rice The milling properties of pearl millet were mainly affected by kernel size, shape and hardness Parboiled pearl millet did not develop the off-flavor that occurs in pearl millet products

Future Directions

INTSORMIL will continue to jointly plan and execute collaborative research that benefits developing countries and the United States 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 pearl millet production These ties are envisioned to be 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 INTSORMIL will use five specific strategies to maintain its current momentum, build on its record of success and accomplish a new set of goals These strategies are (1) sustainable research institutions and human capital development (2) conservation of biodiversity and natural resources (3) research systems development with focus on relevant technology generation (4) information and research networking and (5) demand driven processes

INTSORMIL Global Plan



Constraints

Education

Programs

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

← Mentoring →

Research

Technical Thrusts

- Germplasm Enhancement
- Sustainable Production Systems
- Sustainable Plant Protection Systems
- Crop Utilization and Marketing

Educational Outcomes

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

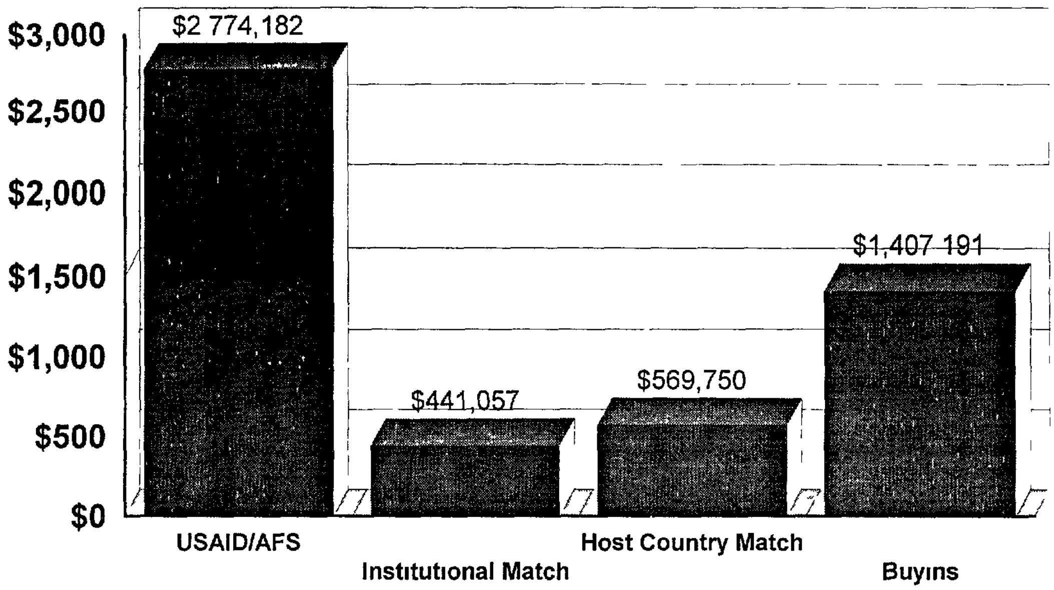
Research Outcomes

- 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
- Development of Sustainable Food Technology Processing and Marketing Systems

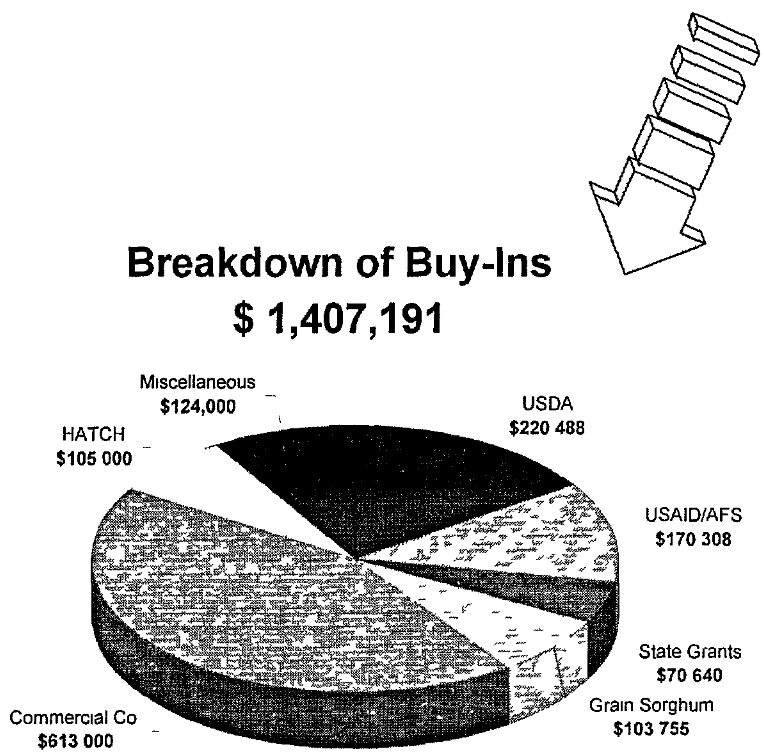
Networking Communication

Farmers

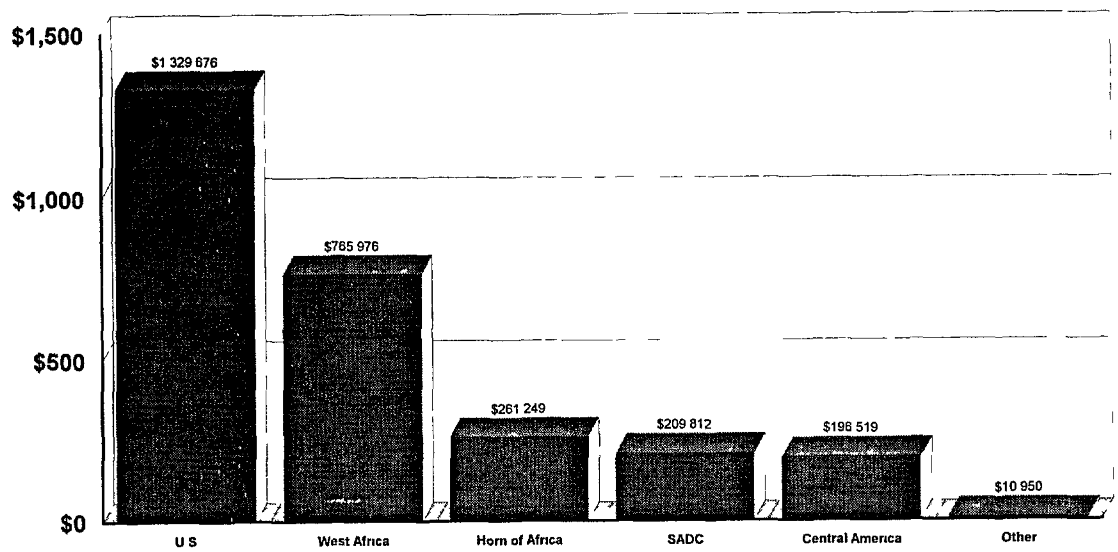
INTSORMIL FY 97 Source of Funding
Total Year 18 -$ 5,192,180



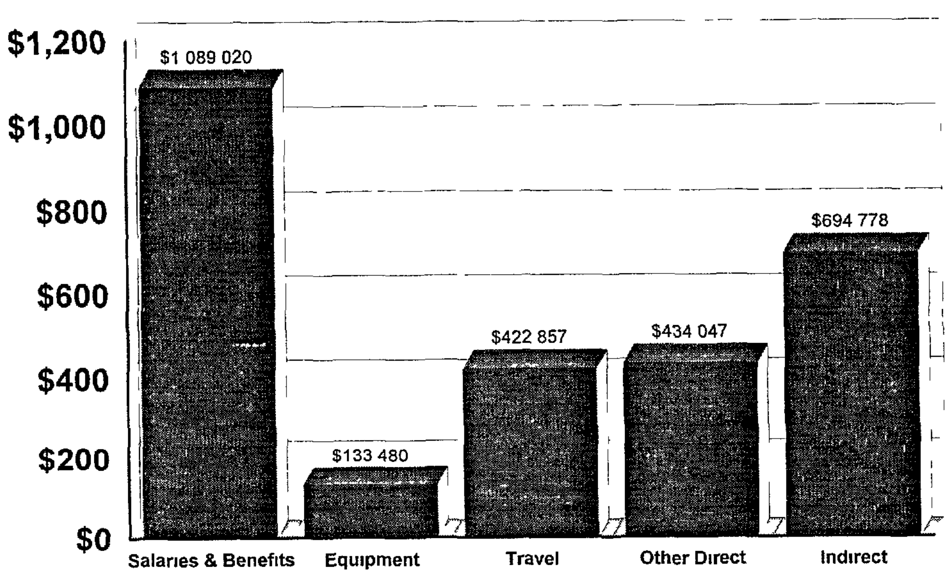
Breakdown of Buy-Ins
$ 1,407,191



INTSORMIL Budget Analysis - Year 18 - FY 97
Functional - $ 2,774,182

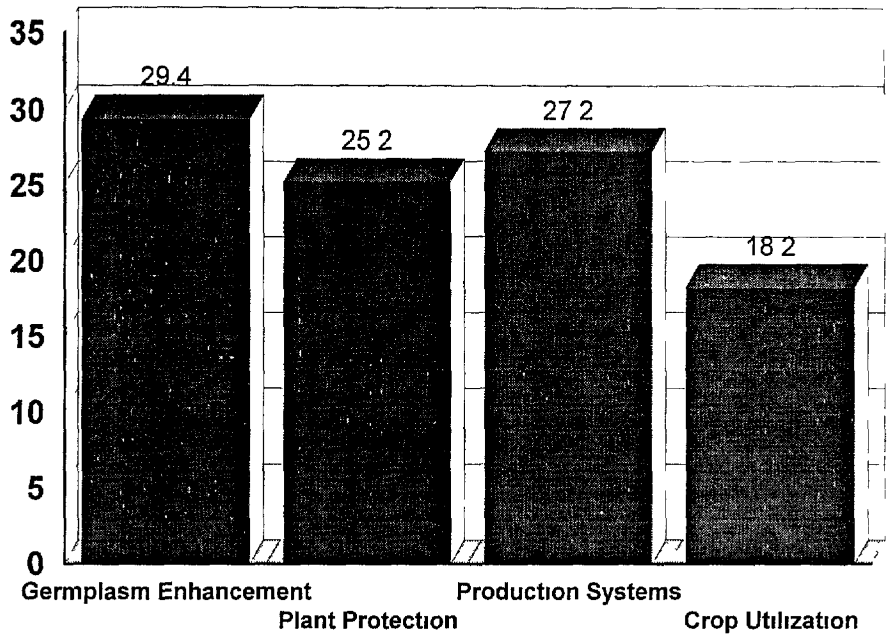


By Region

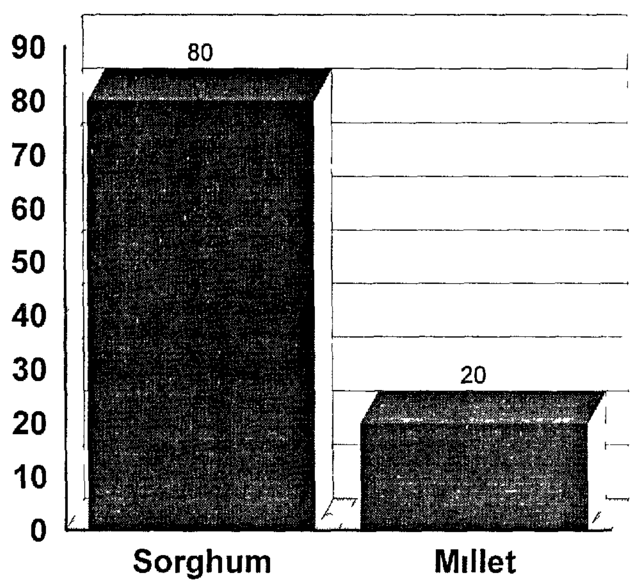


By Line Item

INTSORMIL FY 97 Technical Budget Analysis
Year 18 - $ 1,672,000



Technical Thrusts - By Percentage



Crops - By Percentage

Table 1 USAID-Grant Contribution to Sorghum/Millet CRSP for Years 1 (FY80) through 18 (FY97) for all Collaborative Research and Management Entity

Budget Line Items	FY 80-96 Years 1-17	FY 97 Year 18	FY 80 97 Totals
Salaries & Benefits	$ 20 635 113	$ 1 089 020	$ 21 724 133
Equipment & Facilities	2 286 551	133 480	2 420 031
Travel	5 167 993	422 857	5 590 850
Other Direct Costs	4 802 826	434 047	5 236 873
Networking	570 090		570 090
LDC Special Projects	4 357 186		4 357 186
Mission Buyin	100 000		100,000
Indirect Costs	11 286 941	694 778	11 981 719
Total	$ 49 206 700	$ 2 774 182	$ 51 980 882

Table 2 USAID-Grant Contribution to Sorghum/Millet CRSP for all Collaborative Research Year 18 (FY 97), July 1, 1996 - June 30, 1997 USAID Grant LAG-G-00-96-90009-00

	KS	MS	NE	PR	TX	Inst Total	ME Spec Proj	ME HC	ME	Total
Salaries	30 214	28 838	126 685	228 711	213 377	627 825	94 694	97 101	269 400	1 089 020
Equipment		1 249	21 531	4 500	31 200	58 480	9 000	62 000	4 000	133 480
Travel	27 500	11 000	22 011	78 180	92 574	231 265	104 992	53 000	33 600	422 857
ODC	3 930	8 749	37 489	153 951	71 811	275 930	40 218	80 899	37 000	434 047
Indirect	28 356	20 164	62,284	201 658	166 038	478 500	65 496		150 782	694 778
Total	90 000	70 000	270 000	667 000	575 000	1 672 000	314 400	293 000	494 782	2 774 182

Table 3 Management Entity Office Budget Details for Years 1 (FY 80) through 18 (FY 97)

Budget Line Item	Years 1-17 FY 80 96	Year 18 FY 97	Total
Salaries and Benefits	$ 2 678 299	$ 269 400	$ 2 947 699
Equipment and Facilities	46 534	4 000	50 534
Travel	830 456	33 600	864 056
Consultants	44 600		44 600
Other Direct Costs	407 671	37 000	444 671
Indirect Costs	1 608 684	150 782	1 759 466
Total	5 616 244	494 782	6 111 026
Workshops	61 000	50 000	111 000
EEP	180 000	10 000	190 000
Special Projects	233 400	64 400	297 800
ME Total	$ 6 090 644	$ 619 182	$ 6 709 826

Table 4 Summary of Non-Federal Matching Contributions by U S Institutions - Grant Years 1 (FY 80) through 18 (FY 97)

U S Institution	Years 1-17 FY 80 96	Year 18 FY 97	Total
University of Arizona	$ 149 310	$	$ 149 310
Florida A&M University	23 898		23 898
University of Kentucky	215 649		215 898
Kansas State University	1 789 021	33 063	1 822 084
Mississippi State University	923 619	17 500	941 119
University of Nebraska	2,140,252	91,050	2,231,302
Purdue University	2,666 489	159 161	2,825 650
Texas A&M University	4,342 972	150 685	4 493 630
Total	$ 12 251 210	$ 451 432	$ 12 702 642

TRAINING

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

The most frequently used mode of training is graduate study for advanced degrees, with the students' research forming an integral part of an INTSORMIL project During the year covered by this report, 56 students from 21 different countries were enrolled in an INTSORMIL advanced degree program Approximately 80% of these students come from countries other than the U S which shows the emphasis placed on host country institutional development (Figure 1)

INTSORMIL also places a high priority on training women which is reflected in Figure 2 In 1997, 16% of all INTSORMIL graduate participants were female Eighteen of the total 56 students received full INTSORMIL scholarships An additional 21 students received partial INTSORMIL funding and the remaining 17 students were funded from other sources as shown in Figure 3

All 57 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 1996-1997 this had decreased to seventeen

In addition to graduate degree programs, short term training 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 one visiting host country scientist were provided the opportunity to upgrade their skills in this fashion during 1996-1997

The following table is a compilation of all INTSORMIL training activities for the period July 1, 1996 through June 30, 1997

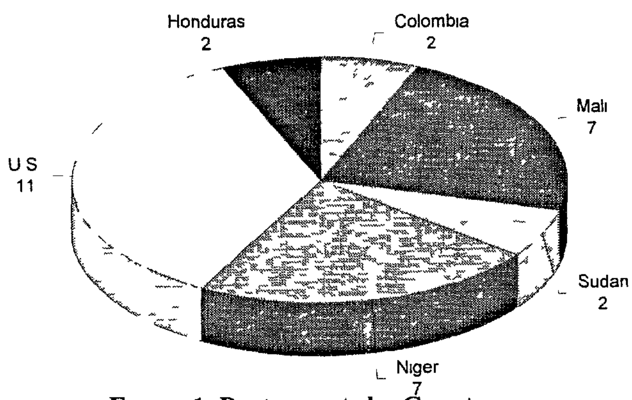


Figure 1 Participants by Country

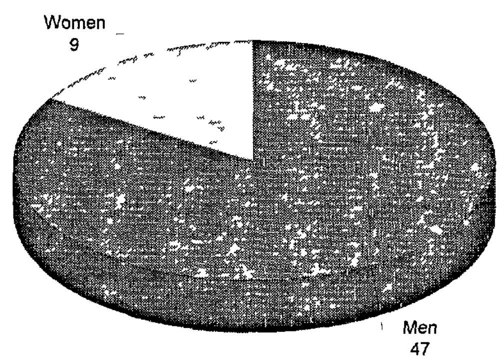


Figure 2 Participants by gender

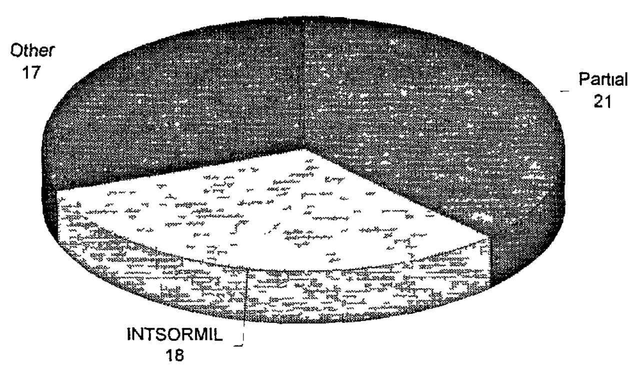


Figure 3 Source of Funding

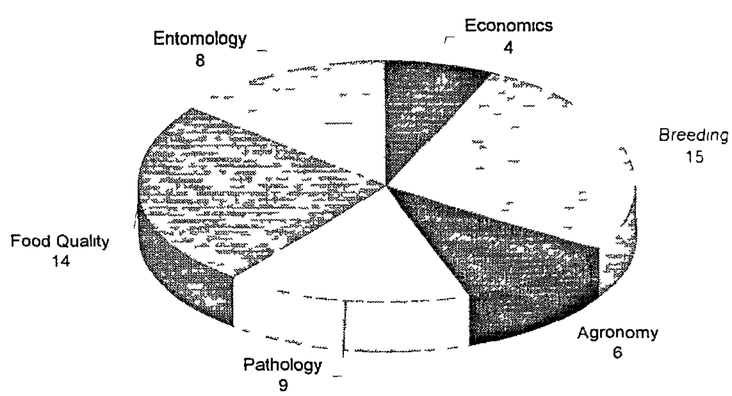


Figure 4 Discipline Breakdown

Year 18 INTSORMIL Training Participants

Name	Country	Univ	Discipline	Advisor	Degree	Gender	Funding*
Gutierrez, Patricio F	Ecuador	UNL	Agronomy	Clegg	PHD	M	I
Masi, Cassim	Zambia	UNL	Agronomy	Maranville	PHD	M	O
Traore, Abdoulaye	Mali	UNL	Agronomy	Maranville	PHD	M	I
Maman Nouri	Niger	UNL	Agronomy	Mason	MSC	M	I
Stockton Roger	U S	UNL	Agronomy	Mason	PHD	M	P
Traore Samba	Mali	UNL	Agronomy	Mason	PHD	M	O
Carvalho Carlos H S	Brazil	PRF	Breeding	Axtell	PHD	M	P
Kapran Issoufou	Niger	PRF	Breeding	Axtell	PHD	M	I
Ndulu Lexingtons	Kenya	PRF	Breeding	Axtell	PHD	M	I
Ibrahim Yahia	Sudan	PRF	Breeding	Ejeta	PHD	M	I
Melakebrhan Admasu	Ethiopia	PRF	Breeding	Ejeta	PD[2]	M	I
Mohammed Abdalla	Sudan	PRF	Breeding	Ejeta	PHD	M	P
Mulatu Tadesse	Ethiopia	PRF	Breeding	Ejeta	MSC	M	P
Tuinstra, Mitchell	U S	PRF	Breeding	Ejeta	PD[2]	M	I
Katsar Catherine Susan	U S	TAM	Breeding	Peterson/Teetes	PHD	F	P
Rodriguez Raul	Mexico	TAM	Breeding	Rosenow/Rooney	PHD	M	P
Teme Niaba	Mali	TTU	Breeding	Rosenow	MSC	M	I
Wiltse Curtis	U S	TAM	Breeding	Rosenow/Rooney	MSC	M	P
Jeutong Fabien	Cameroon	UNL	Breeding	Andrews	PHD	M	O
Setimela, Peter	Botswana	UNL	Breeding	Andrews	PHD	M	O
Tiryaki Iskender	Turkey	UNL	Breeding	Andrews	MSC	M	O
Coulibaly Bakary	Mali	PRF	Economics	Sanders	MSC	M	O
Sidibe Mamadou	Senegal	PRF	Economics	Sanders	PHD	M	O
Tahirou Abdoulaye	Niger	PRF	Economics	Sanders	PHD	M	I
Vitale Jeff	U S	PRF	Economics	Sanders	PHD	M	I
Boire Soualika	Mali	TAM	Entomology	Gilstrap/Teetes	PHD	M	I
Kadi Kadi Hame	Niger	TAM	Entomology	Gilstrap/Teetes	MSC	M	I
Calderon Pedro	Honduras	MSU	Entomology	Pitre	MSC	M	O
Cordero Roberto	Nicaragua	MSU	Entomology	Pitre	MSC	M	I
Vergara, Oscar	Ecuador	MSU	Entomology	Pitre	MSC	M	I
Diarisso Yaro Niamoye	Mali	TAM	Entomology	Teetes/Peterson	PHD	F	P
Jensen Andrea	U S	TAM	Entomology	Teetes	PHD	F	I
Lingren Scott	U S	TAM	Entomology	Teetes	PHD	M	O
Aboubacar Adam	Niger	PRF	Food Quality/Util	Hamaker/Axtell	PHD	M	I
Buckner Becky	U S	PRF	Food Quality/Util	Hamaker	PHD	F	P
Itapu Suresh	India	PRF	Food Quality/Util	Hamaker	PD[2]	M	O
Mamadou Lewamy	Niger	PRF	Food Quality/Util	Hamaker	MSC	M	P
Zhang Genyi	China	PRF	Food Quality/Util	Hamaker	MSC	M	I
Acosta Harold	Colombia	TAM	Food Quality/Util	Rooney	PHD	M	P
Asante Sam	Ghana	TAM	Food Quality/Util	Rooney	PHD	M	P
Bueso Francisco Javier	Honduras	TAM	Food Quality/Util	Rooney/Waniska	MSC	M	I
Floyd Cherie	U S	TAM	Food Quality/Util	Rooney/Waniska	PHD	F	P
Kunetz Christine	U S	TAM	Food Quality/Util	Rooney/Waniska	MSC	F	P
Quintero Fuentes Ximena	Mexico	TAM	Food Quality/Util	Rooney	MSC	F	P
Seetharaman Koushik	India	TAM	Food Quality/Util	Rooney/Waniska	PHD	M	P
Suhendro Elly	Indonesia	TAM	Food Quality/Util	Rooney	PHD	F	P
Zhao Haiyan	China	TAM	Food Quality/Util	Rooney/Waniska	VS[1]	M	O
Diourte Mamourou	Mali	KSU	Pathology	Claflin	PHD	M	O
Lu Ming	China	KSU	Pathology	Claflin	PHD	M	P
Murithi Linus M	Kenya	KSU	Pathology	Claflin	PHD	M	O
Narvaez Dario	Colombia	KSU	Pathology	Claflin	MSC	M	P
Nzioki Henry S	Kenya	KSU	Pathology	Claflin	MSC	M	O
Arjula Vaishali	India	KSU	Pathology	Leslie	MSC	F	O
Zeller Kurt P	U S	KSU	Pathology	Leslie	PD[2]	M	O
Kollo Issoufou	Niger	TAM	Pathology	Frederiksen	PHD	M	I
Torres Montalvo Jose H	Mexico	TAM	Pathology	Frederiksen	PHD	M	O

* I = Completely funded by INTSORMIL
P = Partially funded by INTSORMIL
O = Other source
1VS = Visiting Scientist
2PD = Post Doctoral

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

INTSORMIL Buy-Ins
FY 97

University/ Project No	Buy In	Amount
KSU-210A	Pioneer HiBred	30 000
	USDA/NC Biotechnology	65 000
	USDA/CRS	62 000
KSU-210B	Kansas Grain Sorghum Comm	19,115
		$176,115
UNL-214	Government of Zambia	9 000
UNL-218	Nebraska Grain Sorghum Board	19,640
		$ 28,640
PRF-203	Purdue Agronomy Department	1 000
	Purdue Department of Agriculture	30 000
	McKnight Foundation	30 000
PRF-205	USAID/Africa - Impact Assessment Study	170 308
PRF-207	USDA	37 488
	USDA/ARS	3 000
	Purdue Agronomy Department	1 000
PRF-212	Mahco Research Foundation/India	25,000
		$297 796
TAM-222	USDA/SGC	5 000
	USDA/NRI	15 000
	Sorghum Biotech Partnership	10 000
TAM-223	Pioneer Hi-Bred	20 000
TAM 224	Texas Grain Sorghum Producers	10 000
	USDA	13 000
TAM-225	TAES Research Enhancement Program	10 000
	Texas Grain Sorghum Producers	40 000
	TAMU Interdisciplinary Research Initiative	23 640
	Pioneer Hi-Bred	20 000
TAM-225B	USDA/CSRS	7 000
	TAES	5 000
TAM 226	HATCH	35 000
	HATCH H-8101	70 000
	Texas Grain Sorghum Producers	15 000
TAM-228	USDA	13,000
		$311,640
Central America Regional Program	Commercial Companies	20 000
	ASHA PIONEER ASHA Coodlege Gardener ASSIST	450 000
	AHSA INSTA-PRO	70 000
	AID-PRODEPAH	2 000
	ASSIST	1 000
	Rockefeller Foundation	50,000
		$593,000
Totals		**$1,407,191**

INTSORMIL Sponsored and Co-Sponsored Workshops 1979 - 1996

	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	International Conference on Genetic Improvement of Sorghum and Pearl Millet	Lubbock Texas	9/96
48	Global Conference on Ergot of Sorghum	Sete Lagoas MG Brazil	6/97

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