External Evaluation Report on the Sorghum, Millet and Other Grains (SMOG)/INTSORMIL Collaborative Research Support Program (CRSP)

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List of Acronyms

AC	Advisory Committee
AGRA	Alliance for a Green Revolution in Africa
bmr	Brown Mid Rib
CENTA	Centro Nacional de Technologia Agropecuaria y Forestal, El Salvador
CRS	Catholic Relief Service
CRSP	Collaborative Research Support Program
DRA	Division de la Recherche Agronomique, IER Mali
DSSAT	Decision Support System for Agrotechnology Transfer
CA	Conservation Agriculture
EIAR	Ethiopian Institute of Agricultural Research
EET	External Evaluation Team
EONR	Economically Optimal Nitrogen Rate
FODIS	Food Crop Diversification Support Project
GART	Golden Valley Agricultural Research Trust
ICRISAT	International Crops Research Institute for the Semiarid Tropics
IDRC	International Development Research Center
IER	Institute of Rural Economy, Mali
IITA	International Institute of Tropical Agriculture
INRAN	Institut National de Recherches Agronomiques du Niger
INTSORMIL	International Sorghum/Millet, Collaborative Research Support Program (CRSP)
IPM	Integrated Pest Management
ITA	Institut de Technologie Alimentaire, Senegal
IWMI	International Water Management Institute
MARC	Melkassa Agricultural Research Center
ME	Management Entity
NARES	National Agricultural Research and Extension System
NGO	Non-Government Organization
NUE	Nutrient Use Efficiency
OSU	Ohio State University
PI	Principal Investigator
PROMEC	Program for Research on Mycotoxicology and Experimental Carcinogenesis, South African
QTL	Quantitative Trait Loci
SIMLESA	Sustainable Intensification of Maize-Legumes in Eastern and Southern Africa
SMOG	Sorghum, Millet and Other Grains
SSA	Sub-Saharan Africa
TC	Technical Committee
UNZA	University of Zambia
USA	United States of America
USAID	United States Agency for International Development
WWF	World Wide Fund
ZARI	Zambia Agricultural Research Institute

Executive Summary

A number of the main conclusions of the 2006 Battelle Report easily hold six years later. Since 1979, INTSORMIL has assembled the leading US talent in basic and applied research on plant breeding/genetics, crop protection, food science and marketing of sorghum, millet and minor grains in developed and developing countries. In turn, these scientists have identified and brought the most promising young professionals from a range of countries in Central America and Africa at US land-grant universities, in accordance with Title XII. High-quality training, applied research conducted in a realistic world context, and mentoring have established valuable lasting relationships that contributed to further scientific advances. Thus, our major conclusion is that INTSORMIL has done an exceptional job on scientific research, training, and mentoring, on a very small budget. In fact, most of the investment has not been made by USAID but by US land-grant universities and scientists themselves—which means a high payoff to each dollar committed by USAID.

The SMOG CRSP/INTSORMIL is a large program that involves six universities in the USA and 20 countries in East, West and Southern Africa and Central America. Areas of research and development activities include sustainable plant protection and production systems, germplasm enhancement and conservation, crop utilization and marketing, and capacity building, organized into research groups by discipline. Sustainable plant protection and production systems include the pathology group, the entomology group, and the soil, water, nutrient and crop management programs. We discuss each activity area, or group, below.

The pathology group in SMOG has evolved over the years. As a direct consequence of retirements and declining funding, fewer US pathologists are now involved in the SMOG/INTSORMIL CRSP. This has moved pathology research away from more applied screening for various pathogens, which is now accomplished primarily through the breeding efforts of trained plant breeders in country, to the current pathology research on *Fusarium* that is led by Dr. John Leslie of Kansas State University. INTSORMIL initially had an intensive educational effort that included a number of pathologists. Given the limited funding opportunities and loss of those trained pathologists, it is difficult to foresee a future generation of highly trained pathologists. Efforts are needed to identify key training facilities in Africa and to maximize the limited funding available to the project and get more training per dollar. Lack of funding also limits the scope of the research to a few pathogens. Though *Fusarium* is a major health issue and causes various stalk, leaf and panicle diseases, it is not the only pathogen in Africa that causes losses in productivity in either sorghum or millet.

The entomology group led by Dr. Bonnie Pendleton concentrates on insects that cause damage in the field and the team has worked with plant breeders, IPM agents, pathologists, and extension agents to deliver improved cultivars and IPM technologies to rural farmers in Africa. The research team has spent a great deal of time studying the life cycle of many of the important insects in both the US and Africa to better understand the potential for control of those insects through means other than chemicals. Because of the limited number of people working in this area, this research team is responsible for a wide range of insects, covering stem and panicle damaging types to stored grain insects, which have

impacts both in the US and Africa. Research varied from very applied, such as the use of surveys of traditional African farmers to research their understanding and control of insects and traditional screening of breeding material for resistance to insect damage, to the use of sophisticated SEM backscatter detectors to understand how the physiology of sorghum grain impacts damage caused by insects.

Soil, water, nutrient and crop management programs within SMOG are divided into two projects, one concentrating on West Africa, while the other has primary responsibilities in East and Southern Africa. The project headed by Dr. Vara Prasad at Kansas State University has four major goals: technology transfer to farmer's fields; research on the impact of drought and high temperature on sorghum and millets; sorghum response to nitrogen applications; and, long-term training of scientists. Dr. Wortmann's program from University of Nebraska has concentrated on Eastern and Southern Africa, where management strategies are important tools for striga (parasitic flowering plant) control. In Africa, the primary focus is on field demonstrations and evaluation of various cropping systems. As is the case in similar types of applied research programs, results have varied due to soil types, environment, and other constraints. Overall, the trends indicate that many of the demonstrated systems had positive impacts upon grain yields. Technologies such as micro-dose fertility, tied ridge systems to trap more rainfall, contour ridging and use of improved cultivars all demonstrated improved yields throughout the region. Work in the US concentrated on more rigorous evaluation of Nitrogen Use Efficiency (NUE) in sorghum, which included identification of new sources of germplasm that could have potential in the development of improved hybrids and cultivars in both the US and Africa and research on heat stress on millets.

The germplasm enhancement and conservation group has traditionally been one of the most strongly supported and active groups in INTSORMIL and continues to play an important role in the overall success of the program. The group is made up of four US scientists and has recently lost one due to retirement, the only dedicated millet pathologist/breeder in the group. The group continues to work with a strong cadre of African and Central American scientists. Those scientists represent 28 scientists in the US, 23 in Africa, one in Europe, and four in Central America. The programs span most of Africa and some of Central America with a great deal of support from research scientists in the US. The research work involves traditional breeding and use of molecular markers to improve selection efficiency and basic work on striga biology. Forty one sorghum varieties and two pearl millet varieties have been released for a range of uses by the project since 2006. However, there is a lack of a truly viable seed industry that will effectively increase and distribute these important releases in the near future. Because production of sorghum/millet seed is not well addressed by private as well as government parastatal seed companies in host countries, focus on the seed systems is important in the future as availing quality seed in sufficient quantity and quality is part of the value chain in the production to consumption continuum.

Since 2006, there has been a marked emphasis on marketing and utilization across the regions, in recognition of the need to "pull" the adoption of promising new technologies by driving the demand for them. The SMOG CRSP project added a marketing plan to its newly introduced technologies to the farming communities in West Africa. The objectives of the Production-Marketing Project at Purdue

University have been to raise both farm yields and grain prices paid to farmers, and establish 20-30 cooperatives. Farmers' organizations are strengthened through marketing strategies that include grain storage and inventory credit, and carefully timed, direct sales of clean grain to end-users (processors, feed producers). Evidence suggests that these objectives have largely been met. The pilot approach involved working through an existing association or forming a new one in each village. Inputs are financed by the project and farmers are required to repay in kind to the farmers' association. The farmers' association then stores the cereals and sells before the next planting season to provide credit, demonstrating to farmers how they can reduce the effect of the annual price collapse at harvest with storage and establishing a revolving fund.

Another market development project has been started in Southern Africa during the current phase of SMOG CRSP by Ohio State University (OSU). The PIs worked closely with strong host-country PIs at Sokoine University (Tanzania) and the University of Zambia, while mentoring a number of MSc and PhD students, the team wove together a strong body of research in a small time period with limited INTSORMIL funding through tuition waivers and other arrangements supported by OSU. PIs and students succeeded in a) identifying strong potential demand for sorghum in (i) clear beer production and (ii) feed concentrates; b) evaluating on-farm constraints to adoption of improved seed and attaining more technical efficient sorghum production; c) assessing constraints in the seed value chain; d) laying the conceptual framework and collecting the data necessary to analyze price variability and the potential impacts of storage and inventory credit arrangements on farmer income. So far, research on this project has shown limited potential for medium- or larger-scale processing without major institutional investments and substantial increase in sorghum production.

Perhaps the most binding of constraints for INTSORMIL in Eastern and Southern Africa (ESA) is policy. In contrast to the Sahel governments, in ESA not only prioritize maize research over other cereals, but also implement seed/fertilizer subsidies that distort the profitability of maize for smallholder farmers. Subsidies both lead farmers to re-allocate more land to maize hybrids and away from crops such as sorghum and "crowd out" the commercial seed industry, offsetting the positive effects of seed liberalization. Unfortunately, USAID Feed the Future priorities in this region also center on maize, implicitly supporting an approach that is fiscally unsustainable (as it was in the 1980s-90s when parastatal market systems were dismantled during structural adjustment). Fortunately, at least in Zambia, the latest policy documents also recognize the need for crop diversification as a strategy for sustainable growth.

Pertaining to sorghum/millet utilization, the project in West Africa aims to create competitive, value-added products through introducing improved processing technologies and forge direct linkages between processors and farmers, who are paid a premium price for clean grain. In this region, INTSORMIL PIs have applied the "incubation" business model in order to organize small-scale sorghum and millet processors, many of whom are women. They recognized that as in the multi-national food business of developed countries, entrepreneurs in the West African Sahel require technical backstopping to become commercially successful. Product testing among consumers has demonstrated the potential for high-quality, processed sorghum and millet products, such as couscous, that save labor time in preparation. The underlying hypothesis of the work in West Africa is that sorghum can become

an attractive consumption item for higher income urban consumers, and not just poor urban and rural consumers.

The Poultry Industry Project has worked to assemble a team of US and host-country collaborators to focus on educational and promotional programs related to expanded use of sorghum as poultry feed. The premise of the project is that growth in the poultry industries of countries in Central America and West Africa has the potential to not only diversify farm production and generate substantial income, but also to develop an alternative market for sorghum and millet and a healthy livestock feeding sector. Another project (Healthy Foods Project) emphasizes the improvement of food and nutritional quality of sorghum to enhance its marketability in wholesome, convenience foods. Long-term and short-term training in food science is a major component of this project, as well as practical technical assistance in supply chain management and processing technologies. Activities are conducted through CENTA in El Salvador, and in both El Salvador and Nicaragua, and involve substituting wheat flour in various foods. Research continues in this project on the health benefits of various types of sorghum products, including antioxidants, digestibility, and glycemic index. Overall, it seems that much of the work in several of the utilization projects focuses too heavily on promotional efforts that are not linked to other INTSORMIL activities and thus have few discernible impacts. However, there also seem to be little means by which to evaluate the impacts of some marketing and utilization activities.

The EET believes that more rigorous methods of monitoring and evaluation are needed in the next phase of SMOG CRSP, particularly for marketing and utilization, as compared to germplasm enhancement. In 2010, as directed by USAID, INTSORMIL allocated funds to impact analysis. In addition to meta-analyses and case studies of germplasm impacts, products included several MSc theses that evaluated the potential and actual impacts of research investments in value-addition, and an in-depth assessment of the impacts of long-term training. All of these products are of high research quality, and articles developed from the findings will be submitted to refereed journals. In addition, the way the work was executed suggests that the teams coordinated their efforts thoughtfully with other stakeholders, such as host-country collaborators and ICRISAT. Students who participated in several of these studies were interviewed, and acknowledging the educational benefits working with INTSORMIL scientists in addition to their own academic advisors.

Since 2006, the training program of INTSORMIL has continued to build the scientific capacity of professionals in Central America and Africa through graduate studies for advanced degrees and short-term training. From 2001-2007, at total of 116 students from 28 countries were enrolled through INTSORMIL in an advanced degree program, with 70% originating outside the US. From 2008, the numbers of long-term and short-term trainees have been stable at 40-46 and 10-11, respectively, with more than 70% of students from countries other than the US. From 2008, compared to earlier years, food science has been the most heavily represented discipline, reflecting the emphasis of the grant on utilization. A number of agricultural economists have also been trained. Other disciplines included economics, entomology, pathology, plant breeding, agronomy, and more recently, animal nutrition. This distribution departs from earlier periods, in which greater emphasis was placed on plant breeding. The EET considers this to be a positive change.

With respect to gender, women represented 31% of long-term trainees in INTSORMIL projects, but this share grew to 45-48% in each year since 2008. Given the disciplinary emphasis of training on food science, this representation appears to be both equitable (representative of the disciplines) and equal (nearly 50%). A survey of 125 agricultural research and higher education agencies in 15 SSA countries shows that the proportion of women employed in food and nutritional sciences (44%) is substantially higher than in other disciplines. The proportion in agricultural economics is 24%, nearly 24% in entomology, and lower in agronomy, animal science and crop science. In terms of INTSORMIL staff representation, only one of the US PIs, and few of the international PIs are women. This representation is, however, largely outside the control of INTSORMIL and is a reflection of the composition of university staff, those who respond to requests for proposals, and staff of in-country national agricultural research and extension systems. The administrative staff of the ME is composed of women who are highly committed to their work and state that they have adequate professional opportunity.

In addition to the core INTSORMIL program, the ME handled two associate awards during the current phase. The associate awards were useful to leverage the research and development activities of INTSORMIL. The Mali Associate Award and the brown midrib (bmr) sorghum associate award for Central America, enabled INTSORMIL to better address the objectives of establishing partnerships and networks by engaging a wider range of stakeholders such as NGOs, farmers' associations, and professional associations of bakers and processors. The EET considers that the type of scaling-up of proven research concepts that has been attained through associate awards provides one model for the future of INTSORMIL.

The EET undertook an electronic survey and site visit of some host countries as part of SMOG CRSP evaluation. Forty-eight researchers related to INTSORMIL responded to the survey and over 84% of them reported that they focus their efforts on sorghum, underscoring the lack of research on millet and other minor crops. Nonetheless, only about a third reported that sorghum is "very important" in terms of production or consumption in their country. Importance in trade was generally low, as expected, and the importance of millet as a crop was rated even lower. This confirms that INTSORMIL's crops are often economically minor, but also that some prioritization is possible by country according to economic importance. About half of the respondents reported that the financial contribution of INTSORMIL was important or very important in their research budget, which attests to the limitations of their budgets, and to how much a marginal dollar can mean to an underfunded research institution.

Two host countries- Ethiopia and Zambia were visited in April 2012 by an EET member. The visit to Melkassa Agricultural Research Center (MARC) of the Ethiopian Institute of Agricultural Research (EIAR) near the city of Nazreth, and the headquarter of EIAR in Addis Ababa, Ethiopia, was carried out on April 5-7, 2012. SMOG CRSP researchers in Ethiopia work on improved variety development (breeding), soil, nutrient and water management, crop protection, food science and technology transfer, mainly on sorghum and peripherally on millet and teff (*Eragrostis tef*). Almost all the senior and experienced researchers with PhDs have left MARC for other jobs and for postgraduate studies. The current researchers are young recruits and some of them have MSc degrees. The researchers acknowledge that the work they are doing is jointly developed with the US partners (Dr. Ejeta and Dr. Wortmann) and their partnership is also effective. Their work is monitored by the US PIs every year and through regular

contact via e-mail. Their main concern is that there is an overall funding limitation from the SMOG CRSP as compared to the earlier INTSORMIL periods. They fully support the continuation of the SMOG CRSP and would like to continue their work along the value chains of SMOG crops. The need for more funding to disseminate the already available technologies was emphasized. They also expressed their desire to work on crop management practices in teff, a staple cereal crop of Ethiopia that grows on 2.7 million hectares of land annually. Because teff occupies many hectares in Ethiopia, the government wants serious work to be done to enhance its productivity per unit area in its agricultural transformation plan.

A similar visit was made to the Golden Valley Agricultural Research Trust (GART), Zambia Agricultural Research Institute (ZARI) and University of Zambia (UNZA) in Lusaka. Development of improved varieties, value addition and market development are the areas of SMOG handled by researchers in cooperation with US PI's. The sorghum breeding work is led by a senior scientist Dr. Medson Chisi, who is also Deputy Director of Research Services (all research stations) in ZARI. Dr. Chisi has been involved in INTSORMIL for a long time and also assists sorghum breeding in Southern Africa countries. Mr. Muuka handles pearl millet breeding at Mongu Station, Western Zambia. He is also registered as a PhD student in the University of Zambia. The socioeconomics work on SMOG is led by Dr. Gelson Tembo and Mr. Moonga leads the food science work. Dr. Chisi acknowledged that the sorghum breeding program wouldn't have been successful without INTSORMIL/SMOG support. Many research supplies like crossing bags are obtained from the US partner. SMOG also helped in covering operational expenses of trials, meetings with industries and other partners, in organizing field days, and acquiring research facilities. INTSORMIL has developed varieties for Zambia, but lack of seed systems and awareness are bottle necks in technology transfer. Farmer's cooperatives are formed to contribute to technology transfer. Researchers from the UNZA handle value addition and food science components of the value chain. Dr. Tembo, who is leading the market study at UNZA expressed that the partnership with US PI's (Drs. Mark Erbaugh and Donald Larson) works well. Collaboration of UNZA researchers with the US PIs is strong, but there is no collaboration with the breeders at GART/ZARI within Zambia. The food science component is led by Mr. Moonga. The work started by doing a survey to understand the problem. Quality of sorghum grain for market was poor due to mixed seeds and inert materials and hence getting good quality seed for processors has been a problem. Generally, there is a need for SMOG CRSP at the host country level to be multidisciplinary along the value chain of SMOG CRSP crops. Work in Zambia is carried out in more than one institution and information doesn't flow to the breeder and vice versa. More collaboration and interaction are necessary as researchers from different institutions are addressing components of the same value chain of sorghum. In general, creation of a strong and cohesive SMOG team in host countries is necessary to foster in-country partnerships, promote the value chain work effectively and serve as a champion for sorghum and millets.

With respect to SMOG CRSP management, the primary role of the ME has been to understand the complex requirements and paperwork of USAID. The ME has led the development of the award to renew the program every five years, and has more recently have helped secure Associate Awards that were used to supplement project activities. The ME team is also responsible for the RFA development that is used to award projects within SMOG, which requires developing, advertising, and reviewing proposals throughout the lifespan of the primary award. The staff is charged with reviewing, collating,

and publishing annual reports. The ME has both scientific and technical skills but it is unclear how these skills aid the PIs in their scientific research, other than as a liaison between USAID and PIs, and as a guide to ensure that goals and objectives are in line with FtF.

The strongest aspect of the ME is the quality of its staff. This small group of dedicated and talented individuals is responsible for the overall management of SMOG that includes, but is not limited to, the administration of primarily foreign graduate students, funding allocation, accountability, travel arrangements, meeting development and coordination, and the ever expanding volume of documents and publications to collect and distribute.

The financial management of the ME has been excellent, despite crucial delays in receipt of USAID funds that have jeopardized project implementation, as was the case this year. Fortunately, the University of Nebraska has "loaned" funds to the ME to ensure that programs continue to function with the understanding that these funds will be reimbursed.

The primary area of the EET concern with respect to the ME is not its performance of current functions, but the functions that it could undertake as a leader in a globally recognized, important research alliance. The EET had expected to find an overarching strategic vision of the future of INTSORMIL and the roles and responsibilities of the ME, spelled out in a public document and well understood by all ME staff. Defining this strategic vision should be the role of the Board, based upon the feedbacks from the ME and PIs. Technically, the ME is quite skilled at navigating the ever-changing waters that make up USAID and the shift in focus and commitment that result from political constraints. The ME is forced to concentrate on maintaining the core funding of USAID and to continually justify its funding base. The output of the PIs far exceeds the limited funding they receive because PIs are eminent in their field, attract over funds, and use their time effectively.

A second concern of the EET is the sense that the ME is so focused on the relationship with USAID that it limits its ability to diversify funding. A forward-looking ME should have the skills to better position SMOG in the competitive world of funding. This ME clearly has a superior program to offer other donors. The EET believes that expanding the funding portfolio of SMOG would allow it to develop and implement successful programs, and make better use of the incredible scientific personnel and research database it has formed over the lifespan of INTSORMIL, for the benefit of world agriculture.

A third concern relates to technical and strategic oversight. The influence of the Board of Directors in the overall success of SMOG was unclear to the EET, aside from meeting occasionally to approve policy and procedures or the decisions related to a project review. The dissolution of the Technical Committee, which served for critical peer review, is also troubling. Moreover, excellent Boards and TCs are generally composed largely of outside experts who can help guide, reflect upon, and advise the ME and PIs on the direction of SMOG, expanding its reach, and diversifying its funding. The EET suggests that the composition of the Board and TC be revisited, to better support the mission of the ME.

We strongly endorse the continuation of SMOG CRSP for the coming four years and recommend that the current ME continue to lead the SMOG CRSP during a transitional period of two years. During the

transition, we suggest that the Board and the ME undertake steps toward becoming a leader of a global program.

Our second recommendation is that the current ME be strengthened in order to better raise funds, orchestrate a global strategic program, and monitor and evaluate program impacts and the Board becomes more actively engaged in directing the ME towards this recommendation. This might be accomplished through the following activities, conducted in consultation with INTSORMIL PIs and collaborators (and external experts, if needed):

1. Develop a strategic plan and mission statement that includes a concise statement of ME and INTSORMIL goals, objectives, and activities, articulates program structure, roles and responsibilities, and identifies potential sources of funding.
2. Undertake a thorough exercise in prioritization by developing objective scientific criteria for ranking countries in which work could be conducted and weighting the relative importance of these criteria according to a stated set of program goals.
3. Conduct fund-raising activities and develop proposals in order to diversify the funding portfolio of the program.
4. Establish two committees: a) an independent steering committee to provide guidance on strategic direction and identify funding opportunities, and b) an oversight or technical committee to review the technical quality of research and training activities.
5. Strengthen the monitoring and evaluation capacity of the ME, especially as it relates to marketing and utilization. Impact assessment should address not just plant breeding, but marketing and utilization activities. Attention should be given to appropriate methods.

We recommend that each activity be associated with a specific deliverable that serves a milestone. For example, the milestone associated with activity 3 would be a strong expression of interest on the part of a new donor. Activity 2 would result in a document that records the process and findings of the exercise. Conducting these activities has implications for ME funding during the transitional period. Additional resources will be needed.

The EET makes the following recommendations with respect to the work of the program as a whole:

1. Apply a value chain approach to integrate research and to build greater synergies among projects, based on a focus-country model within a region. The Associate Awards are a good vehicle for designing these approaches in a way that is consistent with FtF.
2. To disseminate technologies widely, and to advise governments based on scientific findings, integrate “vertically” along a value chain but also “horizontally,” in order to reach an array of other stakeholder groups in the countries of focus.
3. Test innovative ways of multiplying and distributing seed to small-scale farmers, and identify those that are successful—encouraging, where feasible, the involvement of commercial companies.

4. Identify key training facilities in Africa and Central America to educate candidates for advanced training in cost-effective ways while strengthening institutions in these regions.

1. Recommendations

Our first recommendation is that the **SMOG CRSP should be continued for another four to five years, based on a proven record of outstanding scientific leadership, training and mentoring**. Like Battelle in 2006, we assert that activities in supply chain management and improvement of profitability because of value-added markets are needed and should be an important major part of the program, including the developing of seed supply channels. This has several implications, if breeding, agronomy and entomology programs are also to be adequately funded. First, additional funds must be generated. We sense that the benefit/cost ratio of Associate Awards, when well-managed, integrated, and building on past investments, as in the two cases mentioned here, is demonstrably high. Second, regional programs should be shifted towards countries of focus. The number of these countries will need to be reduced, following the prioritization we suggest, although focus countries can be embedded in regions and regional activities. Third, 'smart' monitoring, evaluation and impact assessment of these activities will be needed**.** Our sense is that in the first six years of these initiatives, some efforts were scattered, atomistic, and without much demonstrated return to resource (USAID and US University) investment. By contrast, others appear to have been tremendously successful.

Given these implications, our second recommendation is that **the current ME be strengthened in order to better raise funds, orchestrate a global strategic program, and monitor and evaluate program impacts and the Board becomes more actively engaged in directing the ME towards this recommendation.** To achieve this change the Board must become more actively engaged and we recommend a funded, transition period, in which the ME, in consultation with INTSORMIL PIs and collaborations, undertakes several steps as outlined below:

A first recommended step is to **develop a strategic plan and mission statement** that includes a concise statement of ME and INTSORMIL goals, objectives, and activities, articulates program structure, roles and responsibilities, and identifies potential sources of funding. Ideally, this statement would convey a strategic vision of the Board and the role of the ME as leader of a global program of excellence in scientific research and education about sorghum, millet, and minor grains.

A second recommended step is to **undertake a thorough exercise in prioritization** by developing objective scientific criteria for ranking countries in which work could be conducted and weighting the relative importance of these criteria according to a stated set of program goals. Criteria might include area grown in sorghum and millets, importance of these crops in the diet, population living under the poverty line, food security situation, etc. For example, in the countries where INTSORMIL works, sorghum, millet and minor crops are important as food and feed, but underutilized from the perspective of their economic potential. There is a wide range in the importance of these crops in terms of production, end uses, and government policy, as well as alignment with Feed the Future initiatives. There is also variation in the extent to which enhancing their economic value through increasing marketability of the crops and crop products will reduce poverty**.**

A third recommended step is to **undertake fund-raising for the global program**. Until now, the burden of fund raising has fallen largely on individual US PIs. Given their prominence in their fields, many are successful in fund-raising, but not necessarily for the purposes of INTSORMIL or in ways that contribute in a synergistic way to the goals of INTSORMIL. The ME has not undertaken fundraising. As a consequence, the real amounts allocated per project have declined over time, and important functions of INTSORMIL, such as international meetings, network, and internal technical review, have been sacrificed. While the consequence is a high return per USAID dollar invested, returns could be considerably higher with a more integrated, coordinated, well-financed ME and a true "global program." Certainly there are no other competitors among global players except ICRISAT, which has suffered in recent years from declining funds for crop improvement and like many other CGIAR centers, a loss of focus. The CGIAR as a whole is now undergoing major internal changes. The EET is of the opinion that the land-grant basis of INTSORMIL is unique in its long-term training and mentoring. We sense that an integrated, holistic value chain model in one lead country per region stands to generate a much higher rate of return to investment than the piecemeal, scientist-to-scientist, project-by-project model of the past.

A fourth recommended step is to **establish an independent steering or oversight committee** that can support the strategic goals established in the ME plan and assist in identifying funding sources, as well as **re-establish a technical committee** that can provide strong peer review.

A fifth recommended step is to further strengthen **the monitoring and evaluation function of the ME,** especially as it relates to marketing and utilization. Impact work needs to address not just plant breeding, but marketing and utilization activities, and do so with the appropriate methods. As yet, there is no evidence of use of counterfactuals, for example, so that annual evaluations show year-to-year changes in the target population but not between the target population and a control group. On the other hand, the demands placed on the ME in responding to the USAID's internal M and E requirements (and not those specifically related to INTSORMIL) should be re-evaluated.

In addition to strengthening the ME, we recommend change in the underlying conceptualization of the INTSORMIL program. INTSORMIL was originally conceived as a program to improve research capability alone rather than a comprehensive program designed to address all of the challenges in the value chains of these crops, in all of the countries of Africa and Central America. Since 2006, based on the recognition that technology adoption is driven by demand of end-users in an increasingly urbanized, developing world (farmers who are consumers, but also consumers in towns and cities, processors, supermarkets), INTSORMIL has launched several initiatives that focus on product demand. We recommend that **the value chain approach should be applied to integrate research and to build greater synergies among projects, based on a focus-country model within a region**.

Our understanding is that the original INTSORMIL model was a land-grant alternative to the international center model. With a focus on a single commodity, INTSORMIL would "collect" the best commodity researchers available among the land-grant institutions, provide pocket money to enable them to interact and gain experience in developing countries. By attracting other resources, these leaders would support US interests overseas, their universities, and the commodity industry in the US—

a win-win situation. Initially, the innovation approach was a linear one—plant breeders, agronomists and entomologists solved problems and these solutions were transferred into the waiting hands of farmers by national extension services. However, extension services are weak in many countries where INTSORMIL has worked. Sorghum, millet and other minor grains are perceived as poor farmers' crops. With urbanization and rising incomes, these have been substituted by maize and rice. In the meantime, researchers and practitioners increasingly recognized that adoption is driven by demand for the product and not by supply—and that to facilitate innovations in product quality or nutrition that provide incentives to farmers, it is necessary to work with a new array of stakeholders. A shift occurred toward marketing and utilization after the Battelle impact study in 2006. However, this shift was not accompanied by sufficient funds or the change in funding structure needed to accomplish the new goals and objectives. For example, we have seen attempts to engage small-scale processors as individuals but without the platforms needed to engage the industry and policymakers. Those actors who represent the "demand-pull," including the private sector, are still under-represented. Thus, we recommend that to disseminate technologies widely, and to advise governments based on scientific findings, **INTSORMIL and collaborators need to not only integrate "vertically" along a value chain but also "horizontally," in order to reach an array of other stakeholder groups in the countries of focus.**

When a full value chain approach is pursued in one lead country of a region, the ME has the capacity to host international, regional and national workshops with the participation of major stakeholders, and the Technical Review Committee assures strong peer review of research findings, it will also be feasible for INTSORMIL to convey clear policy messages and encourage governments to place sorghum, millet, and minor grains on the economic development agenda in appropriate ways. The economic analyses conducted by the marketing projects are a critical input to these policy discussions. Without conducive policies, even the most promising new sorghum or millet cultivar will not be adopted. Associate Awards are a good vehicle for designing outreach and dissemination strategies in a way that is consistent with FtF. We are of the opinion that **further use of the leader with associate award model should be encouraged.**

The program needs to work on the seed systems of sorghum, millet and the other crops. In some countries modest amount of seed production is done by the researchers and in some cases community based seed production is carried out through organized farmers associations**.** We recommend that **INTSORMIL together with partner countries needs to test different ways of seed multiplication and distribution to small scale farmers and identify those that are successful,** encouraging the involvement of small- and medium-scale commercial companies where possible.

There is a shortage of scientists to work on INTSORMIL crops in SSA as a result of retirement and change of jobs. INTSORMIL initially had a very large educational effort in different disciplines and given the limited funding opportunities and loss of those trained it is difficult to see where the next generation of highly trained scientists will come from. Our final recommendation is that **efforts to identify key training facilities in Africa and Central America need to be done in order to maximize the limited funding for both BS and upper-level degrees.**

2. Scientific and Technical Assessment Overview

The scientific and technical assessment part is divided into six sections. The first section provides an overview of the scientific approach to addressing the issues of "Sustainable plant protection and production systems," the second reviews "Germplasm enhancement and conservation," the third evaluates "Crop utilization and marketing," the forth involves "Training," the fifth section looks at "Impacts," and finally there is a review of SMOGs efforts in "Gender." Moreover, milestones achieved by SMOG/INTSORMIL for the period 2006 – 2012 are shown in Annex B.

2.1. Sustainable plant protection and production systems

The Sustainable plant protection and production systems group is now comprised of four research projects that involve five US PIs and various collaborating scientists. Of those collaborating scientists, 13 are located in the US and one in Europe, while the rest are made up of scientists from various African nations. Two of the projects involve plant diseases and insects while the other two are dealing with soil, water, nutrients and crop management issues. The agronomic projects are divided into two specific regions, West Africa and Eastern/Southern Africa. There has been some reduction in project numbers and PI involvement due to retirements and funding issues within this award cycle.

The pathology group in SMOG has evolved over the years and fewer US pathologists are now involved with SMOG as a direct consequence of retirements and funding reductions. This has moved the pathology research away from more applied screening for various pathogens, which is now done primarily through the breeding efforts of trained plant breeders in country, to the current pathology research that is headed by Dr. John Leslie of Kansas State University. He is recognized as one of the foremost researchers on *Fusarium*. Mycotoxins are a serious health issue in Africa and this broad ranging project concentrates on evaluating the incidence of mycotoxins across much of Africa through collaborative collection and identification of mycotoxins and the fungi that are responsible for these issues in maize, sorghum and millets. *Fusariums* are also a leading cause for stalk rot in both sorghum and millet and their work coupled with plant breeding efforts are striving to identify new germplasm sources of resistance. Overall, the role of the ME is as a facilitator for conferences and meetings, while the PI takes the lead role of coordination of all research activities. The PI has taken advantage of the extensive network of trained INTSORMIL pathologists to establish regional cooperation needed to move the program forward and he has reached out to various international organizations such as IITA and PROMEC in Africa and with European pathology groups to assist in the monumental task of cataloguing and identifying various *Fusarium* species and their impact on mycotoxin production. The program has been a mix of both applied and basic research, with most of the collection and cataloguing occurring on the ground in various African nations, while the more basic genomic identification and work taking place in the US. The basic identification of these different species is using cutting edge genomic tools to more

clearly define the population structures of *Fusarium*, which is critical to our understanding of how the biology of the pathogen evolves throughout the continent and will assist in the development of future management strategies for control of this pathogen. Research activities have been robust and this is reflected in the number of published journal articles and the broad scope of outreach programs with seminars, workshops and invited meeting presentations (See Annex A). It is clear that the PI has done an extraordinary job in reaching out to the scientific community to address the issue of mycotoxin contamination in these crops of interest and research clearly shows some advantage to both sorghum and millet in the control of these contaminants in the food chain, but more work needs to be undertaken to fully understand methods for control of these pathogens to lessen their impact upon the health and nutrition of vulnerable people throughout Africa.

Areas of Concern: There are two major areas of concern. The first is the retirement or loss of pathologists in Africa. INTSORMIL initially had a very large educational effort that included a number of pathologists and given the limited funding opportunities and loss of those trained pathologists it is difficult to see where the next generation of highly trained pathologists will come from. Efforts to identify key training facilities in Africa need to be done in order to maximize the limited funding available to the project and get more training per dollar. The second concern is the lack of funding, which limits the scope of the research to a few pathogens. Though *Fusarium* is a major health issue and causes various stalk, leaf and panicle diseases, it is not the only pathogen in Africa that causes losses in productivity in either sorghum or millet. However, with the limited funding, selected pathogens have to be targeted to ensure maximum impact of the research.

Dr. Bonnie Pendleton has been involved with the INTORMIL team for many years and is one of the few entomologists in the US that works on sorghum or millet. She has a link with a wide range of collaborators throughout Africa and the US and her extensive knowledge on pest biology has been critical to the success of her particular efforts within INTSORMIL. Recently, the group has expanded their research efforts into stored insects, which can cause tremendous losses in Africa. Traditionally the program concentrated on insects that caused damage in the field and she and her team have worked with plant breeders, IPM agents, pathologists, and extension agents to deliver improved cultivars and IPM technologies to rural farmers in Africa. The research team has spent a great deal of time studying the life cycle of many of the important insects in both the US and Africa to better understand the potential for control of those insects through means other than chemicals. Because of the limited number of people working in this area, this research team is responsible for a wide range of insects, covering stem and panicle damaging insects to stored grain insects, which have impacts both in the US and Africa. Research varied from very applied, such as the use of surveys of traditional African farmers to research their understanding and control of insects and traditional screening of breeding materials for resistance to insect damage, to the use of sophisticated SEM backscatter detectors to understand how the physiology of sorghum grain impacts damage caused by insects. The impact of her work can be seen in the publications, workshops, training and student education that she continues to excel at (see Annex A for publications). Dr. Pendleton has also trained several African women over the years and has worked to try to address the issue of gender disparity within the African scientific community. Her

students are highly trained in basic insect biology and applied strategies for control of those insects. It is not clear what the role of the ME is here other than as a facilitator for workshops, training students, etc.

Areas of Concern: Similar to the pathology group, there are two main areas of concern. The first is the lack of trained entomologist in Africa and the potential need for additional training of highly skilled technicians and scientists that are critical to the success of both chemical control of insects and the use of IPM technologies. The second issue of concern is funding. It is extraordinary how much work is accomplished by this group with the limited funds that are available to conduct research, train people, and implement extension activities. They seem to piece together small pockets of additional funding to accomplish goals and objectives.

Soil, water, nutrient and crop management programs within SMOG are divided into two projects, one concentrating on West Africa, while the other has primary responsibilities in East and Southern Africa. The project headed by Dr. Vara Prasad at Kansas State University has four major goals: technology transfer to farmer's fields; research on the impact of drought and high temperature on sorghum and millets; sorghum response to nitrogen applications; and, long-term training of scientists. This project began in 2008 and utilized farmer surveys to identify crop systems and key constraints to productivity. Based on those surveys, research projects were initiated in several countries within West Africa to begin the baseline data collection needed to develop technology transfer programs. In the last several years, research programs took place in Ghana, Niger, Burkina Faso and Mali that evaluated the effects of tillage and nitrogen applications on sorghum (Ghana), tied ridge, fertilizer and population management demonstrations (Niger) and development of cropping management systems in Burkina Faso. In Africa, the primary focus is on field demonstrations and evaluation of various cropping systems. As is the case in many of these types of applied research programs, results have varied due to soil types, environment, and other constraints, but overall the trends indicated that many of the demonstrated systems had positive impacts upon grain yields. Technologies such as micro-dose fertility, tied ridge systems to trap more rainfall, contour ridging and use of improved cultivars all demonstrated improved yields throughout the region. See Annex Table 1 for crop management technologies generated by the project. Work in the US concentrated on more rigorous evaluation of Nitrogen Use Efficiency (NUE) in sorghum, which included identification of new sources of germplasm that could have potential in the development of improved hybrids and cultivars in both the US and Africa and research on heat stress on millets. Several graduate students are being trained and there seems to be excellent coordination with the work that is going on with Dr. Charles Wortmann from the University of Nebraska.

Dr. Wortmann's program concentrates on Eastern and Southern Africa in which management strategies are an important tool for striga control. This is one of the few programs also doing work on a specialized crop of extreme importance in Ethiopia, Teff. The main aim of Dr. Wortmann's project is to increase yield level and stability of sorghum, millet and other grains (teff) through crop, soil and water management (tied-ridge) while sustaining the natural resource base. Its other aim is improving research and extension capacity through effective partnerships with local, national, and international agencies. While doing research to address the main goal, the project identified and promoted promising practices through extension activities in Ethiopia, Uganda and USA (Nebraska). Water conservation, water use efficiency, and nutrient management targeted to striga infested and non-infested areas have been the

research extension activities in the Central Rift Valley and Tigray Region of Ethiopia. Striga is a very important parasitic weed that impacts yields of susceptible crops throughout the region. Moreover, the Ethiopia component involved skip-row planting of sorghum in the Central Rift Valley of Ethiopia. Short-season pulse crop (bean) has been used in the skip-rows in this moisture stressed area of the Rift Valley. However, scientists of the project completed studies on tillage, skip-row planting, and fertilizer use effects on grain sorghum conducted for several seasons. They reported that tied-ridging and skip-row plantings were found to increase grain yield in northern Ethiopia but not in the Central Rift Valley. Planting two rows and skipping one row was the most promising configuration in northern Ethiopia and it did not result in yield loss or gain in the Central Rift Valley. The project also demonstrated mean yield increases of 27% in grain yield and 46% in stover yield with tie-ridging in sorghum as compared with the traditional tillage practice in an on-farm trials conducted for two years in Tigray Region of Ethiopia. The researchers also demonstrated a benefit to cost ratio of 12.2 in teff grain and straw due to N and P fertilizer application in Tigray Region in the early years of the project. In 2010/11, research on management practices of teff, the staple cereal of Ethiopia that grows on 2.7 million ha annually, was not implemented because the responsible researcher left for postgraduate study. The project studied climate variability in Bosset and Meisso districts, Central Rift Valley of Ethiopia, in 2009/10 that included the complex decision processes of farmers, in consideration of recent and developing weather conditions, which are used as a basis for current field and modeling research. A post graduate student at Haramaya University, Ethiopia, is looking various aspects of dry soil planting in response to more variable onset of the rains and the importance of early crop establishment for crop yield and water use efficiency. This research will use the DSSAT model to investigate the probability of increased yields with dry soil planting at different dates compared with planting following true onset of rains.

On farm research and demonstrations are keys to the needed data collection that is being used to enhance modeling programs that assist in predicting the impact of variable environmental conditions which are impacting the region. Studies in Uganda have shown that farmers implementing INTSORMIL recommendations have seed yield increases of approximately 30% compared with farmers not participating in the programs. The economically optimal N rate (EONR) for sorghum was established to be 24 kg/ha in Uganda and fertilizer P applied to sorghum was most profitable at 4 kg/ha and K application was not profitable at any rate. The project developed, fine-tuned (verified) and promoted tillage and soil fertility management practices in striga-infested Eastern and Northern Uganda. Long-term sustainability of these practices is being studied by a graduate student. The project has released three sorghum varieties and more than two tons of seed has been made available to farmers. In Mozambique, N and P fertilizer application increased grain yield of sorghum by 75-100%. The subsequent planned work is to address nitrogen fertilizer profitability and use efficiency as part of a PhD study. In the semi-arid Western Nebraska, the researchers reported that grain yield of sorghum was more stable with skip-row planting than with all rows planted.

In addition to SMOG funds, Dr. Wortmann's project has been able to augment its extension activities through the support of IDRC in promoting soil management technologies in Ethiopia. Moreover, collaborative research has been initiated with IWMI on water productivity and determination of genetic components of important varieties for crop growth modeling. In Uganda, additional funding has been

obtained from AGRA to develop yield response functions to application of applied fertilizers for six crops and of a fertilizer optimization tool for choice of crop-nutrient-application rate combinations for maximization of net returns on investment. As is the case with the plant disease and pest projects, the ME role is one of coordination of academic training, workshop presentations, and financial oversight.

Area of Concern: The primary area of concern is again the lack of funding to expand the programs into areas of greatest need, additional outreach and extension activities. Given the fact that both programs have invested in training students, which takes approximately half of their funding, there is not enough funding to expand their outreach programs beyond their initial regions. Some of this is being addressed by Dr. Wortmann and his collaboration with IWMI, IDRC and AGRA, but without further investment in extension and outreach then the overall impact of the two research programs will be limited to localized regions. While the depth and breadth of research is wide in Ethiopia, it is limited in countries like Mozambique and Uganda and very minimal in Tanzania. It is well known that agronomic practices contribute to yield increase and stability and therefore well planned activities should be carried out in selected countries in a region for better outcome and impact. With the exception of the US partners, there is a shortage of researchers on sustainable production systems in the host-country institutions. The only exception is Uganda where a PhD holder is running the agronomic trials. Because Dr. Wortmann is partnering with individual researcher(s) in a given host country, the activities are not implemented when the individual responsible is leaving the institution for various reasons. A case in point is the non-implementation of the teff crop management practices owing to the departure of the researcher for further study. The EET suggests that projects be institutionalized with host country research establishments so that Institutes assign a new researcher to implement planned activities upon the departure of staff. Some institutions like the EIAR of Ethiopia monitors projects strictly through Directors assigned for various disciplines. Discussions with host country researchers in Ethiopia during the site visit revealed that more funding is needed to disseminate the already available agronomic technologies for wide scale impact. The need for crop management practices in teff was also underlined. Because teff is occupying a large agricultural land in Ethiopia (2.7 million ha), the government wants serious work to be done to enhance its productivity per unit area in its agricultural transformation plan.

2.2. Germplasm enhancement and conservation

The germplasm enhancement and conservation group has traditionally been one of the most strongly supported and active groups in INTSORMIL and continues to play an important role in the overall success of the program. The group is made up of four US scientists and has recently lost due to retirement, the only dedicated millet pathologist/breeder for the group. Also, one other project was discontinued and funds refocused on higher priority research projects. The group continues to work with a strong cadre of African and Central American scientists. Those researchers represent 28 scientists in the US, 23 in Africa, one in Europe, and four in Central America. The programs span most of Africa and into Central America with a great deal of support from research scientists in the US.

Germplasm conservation is a term used to typically describe efforts to curate national and international genetic resources, which entails collection, characterization, and maintenance of important germplasm resources. Clearly, curation of national collections has been a weak spot around the world, with many nations relying on the US national collection and ICRISAT as their primary source of their own germplasm. It was not clear as to how INTSORMIL projects were meeting this particular objective. Though work was being done in the US to characterize panels of sorghum lines identified many years ago by scientists, none of the projects were involved in efforts to ascertain diversity among germplasm collections within host countries, collect accessions to shore up weaknesses within collections, maintain collections, or educate programs on methodologies to accomplish this. Clearly the focus of the programs has been on germplasm enhancement and utilization and not conservation and this should be reflected in future proposals.

Dr. Mitch Tuinstra leads much of the research efforts in West Africa. The program has concentrated in three main areas, development of locally adapted sorghum varieties and hybrids for improved grain quality and feed value, develop and deploy technologies to manage biotic stresses, concentrating on weed control, and mining genes and alleles associated with improved sorghum performance. Focus has been on the development of improved guineas, primarily targeted for food systems for use by subsistence farmers, while the focus on large-seed varieties using caudatum sorghum is for some food systems and for malting purposes. The program has released some improved varieties in both the US and Africa and work continues in partnership with Pioneer, DuPont and Purdue University to bring seed treatment technology coupled with improved lines for use in weed control strategies to Africa. See Annex Table 2 for varieties released by INTSORMIL/SMOG CRSP. This strategy, if cost effective and used could assist African farmers in controlling striga, which, aside from drought, is one of the major pests that have impacted yield progress in the region. Much of the primary work is being conducted in the US, with secondary evaluation and trials occurring in Africa. The stable Dw3 trait is a proof of concept research program aimed at showing how genomic tools can be used to move identified traits much more rapidly into improved sorghum lines. Though this trait does not necessarily impact yield or improve the crop *per se* and would have little impact in Africa, the relevance of the technology could be extremely important to breeding programs in the future.

Areas of concern: Much of the efforts of this program seemed to be concentrated in the US, which is fine; however, there seems to be some decline in the breeding programs throughout the region that could have a significant impact on making progress in the future. Without strong breeding programs in the region, it will be difficult to build the needed germplasm and parental bases that will be required to make progress in the future. Another area of concern for all the breeding programs is the lack of a truly viable seed industry that will effectively increase and distribute these important releases in the near future. Who will increase and distribute the large seeded sorghums or the herbicide tolerant seed is a major question that does not have a clear answer in any of the programs currently underway.

Dr. Bill Rooney leads the breeding efforts in Central America. There are five major objectives within this research project: develop high yielding, locally adapted varieties and hybrids; identify and map genes related to forage yield and quality; identify and characterize genes related to disease resistance; identify and map genes related to grain quality; and, transfer technology to promote the use of improved

sorghums for grain, feed, and forage. The breeding component of this program is very strong and has significant support from CA scientists. Much of the breeding work is being conducted throughout CA and this is reflected in several important releases of improved sorghum varieties that seem to be having an impact on farmer's fields. Sorghum is somewhat unique in CA, since it is viewed as a viable substitute for wheat flour when wheat prices are high. This has generated an interest in the development and marketing of high quality white food grade sorghums. There is also tremendous interest in sorghum for its use as an animal and forage feed. The very active CA breeding programs utilize their US counterpart to further enhance their programs by providing both technical knowledge and applied breeding experience. The US program, as is the case in all the breeding programs, is working to accelerate gene discovery and utilization through their extensive genomics work and these tools will provide needed technologies to the programs in CA so that continued and more rapid progress can be accomplished. As is the case in all the programs, this is long term basic research that the US is capable of doing and breeders and farmers in CA will be able to benefit from the findings of this research in years to come. Because of the strong collaborative network throughout CA, this program received a sub-award to enhance the CA sorghums with the bmr (brown mid rib) trait. The trait has been rapidly introduced into improved CA sorghum varieties and has been tested in both research and farmers fields. Because of this, interest in these improved feed and forage sorghums, coupled with their grain potential will provide for rapid adoption of new bmr sorghums in the region.

Areas of Concern: As with all the research programs, the major concern is funding. All of these programs have leverage relatively weak US financial support into very robust programs that could all suffer serious setbacks if support from the US fails or as in the case of this year is delayed. Most of these programs do not have the financial support to carry on with research until program funds are made available.

Dr. Gebisa Ejeta, 2009 World Food Prize Awardees from Purdue University, leads projects related to two most important constraints of sorghum production in Africa – drought and striga. Drought affects sorghum production in marginal environments every crop season and striga infestation is exacerbated in sorghum areas where moisture is limiting. Dr. Ejeta and his group showed that about 100 million hectares of field crops are infested with striga annually in sub-Saharan Africa. Their project used genetic improvement to develop drought and striga resistant sorghum lines through a collaborative interdisciplinary process involving US based researchers and a number of national agricultural research systems in Africa. Dr. Ejeta leads a laboratory that is specialized in striga studies. The Parasitic Weed Containment Facility at Purdue University is specifically supported by INTSORMIL as a center of excellence for striga studies. This basic research work started with the development of a rapid method of screening individual seedlings of cereal host cultivars for the capacity of their root systems to produce and exude a chemical signal required to trigger germination of striga seeds. Using this method, Dr. Ejeta's group has been selecting breeding materials leading to the development of striga-resistant sorghums released and widely distributed across Africa (see Annex Table 2 for varieties released). In addition to the development of drought and striga resistant sorghum varieties and hybrids, this project has been involved in the deployment of improved varieties with best-bet agronomic practices, work on market opportunities for sorghum production so that incomes of small-scale farmers is increased. Pertaining to striga management, research activities of the project revealed that sorghum management

practices that involved striga resistant variety with N application and tied-ridge tillage was the best to increase grain yield. This practice was found to give grain yield that is 121% higher than the local practice of using local variety planted on flat bed without N fertilizer application. Mean number of emerged striga was 23 times higher in the susceptible local cultivar as compared to the resistant cultivar at physiological maturity. Striga resistant sorghum varieties do not produce root exudates that stimulate striga germination and attachment. In the project it was demonstrated that striga resistant sorghum hybrids were observed to have high yield potential. With respect to drought tolerance in sorghum, the researchers believed that epicuticular wax (EW) plays a great role by reflecting excess radiation during hot dry spells (reflective cooling) and reducing non-stomatal water loss (dehydration avoidance). The group also worked on another abiotic constraint (cold tolerance) of sorghum as part of a graduate student research project. QTL markers were developed and validated for cold tolerance in various genetic backgrounds of sorghum.

The project also addressed quality issues and biofuels in sorghum. A graduate student studied how agronomic manipulation, traditional milling and preparation would impact carotenoid content, stability and bio-accessibility from model porridge foods produced from milled fractions of yellow-endosperm sorghum. The researchers looked into the impact of bagging panicles of sorghum on yellow-endosperm sorghums and found that bagging increases total carotenoid content. On average, the observed increase in total carotenoid content of bagged sorghum grains is consistent with previous observations that carotenoid content increased by 77% when bagged after pollination compared to standard unprotected open flower heads. This project also studied the use of sorghum as biofuels in the USA. It established that *bmr* mutants of sorghum are the most important sources of low cost biofuel producing biomass sources. Lignin changes among the *bmr* allelic groups was found to be associated with up to 25% increase in glucose yield compared to wild type isolines. Further, the researchers of this project developed molecular markers for specific *bmr* alleles that will help to enhance *bmr* lines of sorghum for biofuel production.

The partnership established by Dr. Ejeta and host country researchers is strong and excellent as revealed from site visit discussion in Ethiopia. The breeding activities emanate from national need and strategy. There is frequent visit by the US PI to monitor activities in Ethiopia and interact with local partners. The researchers proudly appreciate the contribution of Purdue University in strengthening sorghum breeding in Ethiopia in capacity building and material supplies. They indicated that breeding supplies that are not available in the country are coming from Purdue. Since 2006, one PhD and one M.Sc. training opportunities have been given. They also value greatly the Toyota Land cruiser vehicle provided by the US PI towards the end of 2005, which is still functional despite accumulating more than 300,000 km mileage. They also have cold rooms availed by the SMOG CRSP.

Areas of concern: Host country reports on the breeding activities of sorghum and millet is missing in the reports compiled by the ME and much of the report is from the US PI. There is a need for a lab based screening for striga and contained facility in East Africa. Genotypes planted for screening to striga on sick plots completely fail at times due to drought and in such cases time is lost in the breeding effort. INTSORMIL has trained a number of researchers from the region, but currently all the experienced and senior sorghum breeders have left EIAR in Ethiopia for various reasons and sorghum breeding is

constrained because of shortage of experienced breeders. Because production of sorghum seed is not well addressed by private as well as government parastatal seed companies, focus on the seed systems of SMOG crops is important in the future as availing quality seed in sufficient quantity and quality is part of the value chain in the production to consumption continuum.

Dr. Gary Peterson, Texas A & M University, leads sorghum breeding in Southern Africa. The overall objective of this project is to develop germplasm, parental lines and cultivars with enhanced adaptation, increased grain yield potential and resistance to multiple abiotic and/or biotic stresses in the USA and Southern Africa countries. Traits in focus have been sorghum midge resistance, disease resistance, grain weathering resistance and post-flowering drought tolerance. Host countries of the project in Southern Africa include Zambia, Mozambique, Botswana, and South Africa. For Southern Africa, primary biotic stress resistance traits are for adaptation to indigenous cropping systems, seedling and adult plant stage resistance to sugarcane aphid, sooty stripe, leaf blight, anthracnose, and grain mold with sorghum midge resistance incorporated as necessary. The partnership worked on breeding for sugarcane aphid resistance to develop improved cultivars suitable for small-holder production systems with resistance to the aphid. The cultivars sought were tan plant and white grain with excellent resistance to aphid and foliar diseases, grain yield at least equal to local checks, and good grain mold resistance. The breeding effort resulted in the incorporation of sugarcane aphid resistance into elite cultivars with excellent grain yield. This project has succeeded in meeting the needs of small-scale farmers growing sorghum in the host countries. Several new improved sorghum lines from INTSORMIL project were found to be equal or better than the local check 'Macia' (2.8 tons/ha) in Mozambique and six of them were released officially in 2012. See Annex Table 2 for varieties released in different countries. The breeding work for sugarcane aphid (*Melanaphis sacchari* (Zehntner)) resistance in sorghum has resulted in an excellent level of resistance and has been successfully incorporated into elite adapted lines. Dr. Peterson's group also carried out a series of replicated trials to evaluate hybrid combining ability and grain yield potential of new germplasm releases and advanced experimental lines in the USA. The INTSORMIL project also contributed in the development of improved varieties for the brewing industry. Populations were developed by crossing the original malting cultivar (*Barnard Red*) from southern Africa with elite adapted cultivars to select for enhanced levels of brewing and malting quality. The work on sorghum midge has resulted in the development of lines with excellent resistance and acceptable grain yield. The project measured its progress by the number of new germplasm or cultivars released that is classed into more than one objective set from the outset. The networking and partnerships among individual researchers and institutions have been very strong. Host country researchers of the project valued their partnership greatly and attribute their success in research to the effective partnership with the US PI. Site visit has been made to the sorghum breeding project in Zambia. Dr. Medson Chisi, staff of ZARI, is the senior breeder who worked with INTSORMIL for long time and materials developed in his station together with Dr. Peterson have been distributed to other countries in southern Africa and some were released in Mozambique in 2012. Dr. Chisi is about to retire and there is no one to replace him to run the conventional breeding program. The relationship/ partnership with the US PI (Dr. Gary Peterson) have been excellent. Communication with the US PI is regular and works well. E-mail has been the best way to communicate and the US PI visits the program one to two times per year. Dr. Chisi has free latitude in coordinating sorghum improvement in Zambia and the region. The SMOG vision is shared by

the local industries and other stakeholders. Sorghum and millet breeding is strong in Zambia and that is the reason for Dr. Chisi to help other programs in the region.

Areas of concern: SMOG CRSP at the host country level should be multidisciplinary along the value chain of SMOG CRSP crops. For instance, SMOG CRSP work in Zambia is carried out in more than one institution and information doesn't flow to the breeder and vice versa. More collaboration and interaction is necessary in host countries as researchers from different institutions are addressing components of the same value chain of a crop.

2.3. Crop utilization and marketing

2.3.1. Marketing

The Production-Marketing project (Purdue University) was motivated by two challenges that are well-known to INTSORMIL PIs based on their long experience (since 1982) in the West African Sahel[1]. First, given the heterogeneity of growing conditions and the severity of poverty in this difficult environment, on-farm demonstrations generally have little influence on cereal producers because they are not credible. Farmers adopt when they observe successful adoption by farmers under their own village conditions. Secondly, cereal producers experience price collapses at each harvest, especially in years of good harvest, and in bad years, due to public intervention in grain markets. Thus, the introduction of any new technology must be integrated with a marketing plan. Project objectives have been to raise both farm yields and grain prices paid to farmers, and establish 20-30 cooperatives. Farmers' organizations are strengthened through marketing strategies that include grain storage and inventory credit, and carefully timed, direct sales of clean grain to end-users (processors, feed producers). Evidence suggests that these objectives have largely been met.

The pilot approach involved working through an existing association or forming a new one in each village. Initially, 50 ha are allocated to men and 10 ha to women (a limit of 1 ha/man and ½ ha for women[2]). Inputs are financed by the project and farmers are required to repay in kind to the farmers' association. The farmers' association then stores the cereals and sells before the next planting season to provide credit, demonstrating to farmers how they can reduce the effect of the annual price collapse at harvest with storage and establishing a revolving fund. In the second year, the project finances another 50 ha for the men (or in some cases 100 ha) and 10 ha for the women (or 20 ha) assuming the farmers have repaid. The farmers' association then opens a bank account. Goals are a size of 150 ha for men

[1] This project was written by Botorou Ouendeba (Purdue PhD in Agronomy, through INTSORMIL), Tahirou Abdoulaye (presently IITA, having received his graduate degree through INTSORMIL) and John Sanders in 2002. INTSORMIL paid for initial activities for two years (2003-2004). The Regional West African office funded it for three years (2005-2007), followed by five years of funding by USAID-Mali (2008-2012).

[2] Women have access to only very small quantities of land and cannot work their own plots land until they have performed their obligations on the family land. When the project provided one hectare to women, women served as proxies for men and did not control the output.

and 30 ha for women, the continuation of the rotating fund so that the association generates a surplus, access to bank credit if need be.

Initially the project focused on model villages (6 villages in Mali, 5 in Niger, and 2 in Senegal). Of these villages, the strongest associations today are 'Tingoni', 'Garasso', and 'Ouallo' in Mali; 'Gabi' and 'Maraka' in Niger, and 'Tchiare' in Senegal. Each of these has over 150 members, good storage facilities, applies many of the marketing recommendations. In 'Tingoni' and 'Thiari', the cooperatives now have access to bank loans for input credits in spite of the lack of collateral.

In each year, the project monitors the yields and net incomes of participating farmers, and the performance of farmer's organizations relative to objectives. In 2009 after the second year of excellent yields of 'Grinkan' in 'Garasso', USAID-Mali asked the project to work with IICEM[3] in scaling up the pilot. IICEM worked through farmers' associations on an estimated 3000 ha in 2010 and another 5000 in 2011 in Mali, building on previous working relationships with the Malian development bank and depositing funds as loan guarantees to arrange credit for farmers. IICEM makes no special provisions to include women, although some women participate.

Areas of concern: Despite the economic centrality of sorghum and millet in the diet of Malians, and its recognition as a priority by Feed the Future, engaging in policy dialogue is critical in West Africa given the sensitivity of farmers' crop choice to relative prices and government involvement. Recently, a subsidy on fertilizer and a long-term decline in cotton prices have contributed to the expansion of maize area in the historical cotton zone, at the expense of sorghum. In North Central Mali, where sorghum is favored over maize, modeling by Baquedano et al. (2010) suggests that the fertilized sorghum technology package is higher yielding than the maize production package. While improved sorghum seed with fertilizer has only a small effect on increasing income, it has a large effect on raising food consumption and reducing food purchases, particularly in poor years, and when combined with better marketing strategies. Coulibaly's model (2012) also shows that when the fertilizer subsidy is removed and cotton prices are at their long-term levels, adoption of the technical-marketing package dramatically favors the expansion of sorghum area rather than maize. Space needs to be created, and funding provided, for policy engagement.

In comparison with the West African project, the New Market Development Project and Marketing Strategies project (OSU), began during the current phase of INTSORMIL, although lead PIs also have extensive experience in the region. Like the PIs of the West African project, the PIs consider that adoption of improved sorghum will be driven by demand generated through new markets, rather than supply of new technology.

By engaging closely with strong host-country PIs at Sokoine University (Tanzania) and the University of Zambia, while mentoring a number of MSc thesis an PhD students, the team wove together a strong body of research in a small time period with extremely limited INTSORMIL funding through tuition

[3] Funded by USAID, the IICEM project is implemented by Abt Associates in partnership with ACDI/VOCA, Sheladia, Inc., and Carana, and "collaborates with IER, DNA, INTSORMIL, and local NGOs to scale up the use of improved millet and sorghum varieties."(http://www.iicem.net/, April 24, 2012).

waivers and other arrangements supported by OSU. PIs and students succeeded in a) identifying strong potential demand for sorghum in (i) clear beer production[4] (Makindara) and (ii) feed concentrates (Mgaya); b) evaluating on-farm constraints to adoption of improved seed and attaining more technical efficient sorghum production (Kilima et al., 2010; Chimai, 2011); c) assessing constraints in the seed value chain (Hamukwala et al., 2012); d) laying the conceptual framework and collecting the data necessary to analyze price variability and the potential impacts of storage and inventory credit arrangements on farmer income. Analyses of farm data show that the challenges to raising sorghum productivity, especially in the face of current policy, are daunting. Using a nationally representative sample of Zambian smallholders (of which only 396 of 8094 farmers grew sorghum, and these grew sorghum along with other cereals), Chimai found that while sorghum growers were producing only 34 percent of their potential output, they were significantly more efficient than non-sorghum growers. So far, research on this project has shown limited potential for medium- or larger-scale processing without major institutional investments; unless there is a substantial increase in sorghum production, "it is unlikely that small-scale farmers can meet the quantity demands of large-scale processors" (Annual Report, 2011: 88). Small-scale processors work informally, part-time, and without contracts, often selling packaged flour in local markets as blends of other grains.

Areas of concern: Perhaps the most binding of constraints for INTSORMIL in Eastern and Southern Africa is policy. In contrast to the Sahel, governments in Eastern and Southern Africa (and USAID) not only prioritize maize research over other cereals, but also implement seed/fertilizer subsidies that distort the profitability of maize for smallholder farmers. Subsidies both lead farmers to re-allocate more land to maize hybrids and away from crops such as sorghum and "crowd out" the commercial seed industry, offsetting the positive effects of seed liberalization. Unfortunately, USAID Feed the Future priorities in this region also center on maize, implicitly supporting an approach that is fiscally unsustainable (as it was in the 1980s-90s when parastatal market systems were dismantled during structural adjustment). Fortunately, at least in Zambia, the latest policy documents also recognize the need for crop diversification as a strategy for sustainable growth.

2.3.2. Utilization

Past work by Dr. Rooney laid the groundwork for the work that has been undertaken in Central America and West Africa on improving the quality, digestibility, and nutritional content of consumer products made from sorghum and millet. The current project in West Africa aims to create competitive, value-added products through introducing improved processing technologies and forge direct linkages between processors and farmers, who are paid a premium for clean grain. In this region, INTSORMIL PIs have applied the "incubation" business model in order to organize small-scale sorghum and millet processors, many of whom are women. They recognized that as in the multi-national food business of

[4] Eagle Lager was successfully launched on the Zambian market in 2005 and in Tanzania in 2007. In Tanzania, the market share of clear beer in the sorghum market grew from 0 in 2007 to 4% in two years (Annual Report 2009). In Zambia, clear beer presents by far the largest industrial market for sorghum (Larson et al. 2006).

developed countries, entrepreneurs in the West African Sahel require technical backstopping to become commercially successful.

In Senegal, Mali, and Niger, the first step was to make processing facilities fully functional by purchasing supplementary equipment or adapting existing equipment. Next, workshops were held with processing partners to demonstrate the capability of the equipment. Local entrepreneurs were then trained in new cereal processing technologies. They have been able to use the equipment on a limited scale, test the product in the marketplace, bring feedback to the Center for further research and development on process improvement, and access investment funds for their own mechanized operations. The work has been most successful so far in Niamey, where an MSc from Purdue (Moustapha Moussa) implements the project. Women entrepreneurs sell in two large supermarkets in Niamey and a range of small convenience stores. The INRAN unit provides continual technical support, assisting the entrepreneurs, and a strong NARS processor association has made the technology transfer scheme function well. Recently, a new grit-based couscous processing technology developed by an INTSORMIL PI (N'Doye, Director of ITA) in Senegal is being transferred to Malian processors. In addition to the establishment of an incubation center at the IER station at Sotuba in Mali, entrepreneur partnerships were established in 'Mopti', 'Bandiagara', and 'Gao'[5].

Product testing among consumers has demonstrated the potential for high-quality, processed sorghum and millet products, such as couscous, that save labor time in preparation. Prices are only slightly lower than imported wheat-based couscous, but millet and sorghum couscous is preferred by some consumers. Satiety tests have also indicated that traditional thick porridges made from sorghum and millet made from sorghum and millet are satiating and provide extended energy (they also have a low glycemic index) relative to other cereals. The underlying hypothesis of the work in West Africa is that sorghum can become an attractive consumption item for higher income urban consumers, and not just poor urban and rural consumers.

The overall strategy of the Poultry Industry Project (KSU 102) has been to assemble a team of US and host-country collaborators to focus on educational and promotional programs related to expanded use of sorghum as poultry feed. The premise of the project is that growth in the poultry industries of countries in Central America and West Africa has the potential to not only diversify farm production and generate substantial farm income, but also to develop an alternative market for sorghum and millet and a healthy livestock feeding sector. Healthy livestock in turn contributes to human nutritional status. Most of the activities undertaken in this project have involved establishing research and practitioner networks, workshops, and "Road Shows" (traveling demonstrations). Regional research activities have been initiated in West Africa through the coordinating efforts of a Kansas State PhD (Issa) whose studies were funded by INTSORMIL and who is based at INRAN in Niger.

The Healthy Foods Project (TAM 103) emphasizes the improvement of food and nutritional quality of sorghum to enhance its marketability in wholesome, convenience foods. Long-term and short-term

[5] Through Mali USAID mission support of the project "Transfer of Sorghum, Millet Production, Processing and Marketing Technologies in Mali", a entrepreneurial-based processing project was launched in 2008 (team consisting of consultant Mamadou Diouf of ITA/Dakar, Y. Koureissi of IER/Mali, B. Hamaker).

training in food science is a major component of this project, as well as practical technical assistance in supply chain management and processing technologies. Activities are conducted through CENTA in El Salvador, and in both El Salvador and Nicaragua, involve substituting wheat flour in various foods. Other main collaborators are located at the University of Pretoria in South Africa. Research continues in this project on the health benefits of various types of sorghum, including antioxidants, digestibility, and glycemic index. Through the work of CENTA, progress has been made in generating a demand for sorghum flour to extend wheat flour in bread and other baked products. According to the lead PI, "the demand was created by very high prices for imported wheat flour, but preference for sorghum continued when wheat prices dropped" (Annual Report, 2011: 98-99). Although the demand for sorghum to replace wheat depends very much on the price of wheat, the processing system is now in place to take advantage of favorable price ratios.

Areas of concern: The Food Entrepreneur/Industry Project (UNL 102) has the objective of knowledge transfer about how to incorporate sorghum and millet into food products using existing technologies, and regarding the quality traits demanded by processors, as well as partnerships and networking in Tanzania (and more recently, Zambia). A number of processors have been identified in Tanzania and training workshops have been conducted. However, it is not clear how processors are systematically identified, how the collaborative work is undertaken, and whether coalitions, platforms, or learning alliances are established for future activities. The continuity from one year to the next is not evident in the Annual Reports. There have been changes in staffing (the lead PI has changed jobs), and other impediments described in the reports. No approach similar to the "incubation model" is described. A more systematic effort also needs to be made in the poultry project, and although there are examples of linkages with the Production-Marketing Project, this work needs to be better integrated into the overall goals of INTSORMIL. Too much of the work seems to involve promotion, and there is no means by which to evaluate impacts. In general, if continued emphasis is placed on marketing and utilization, more rigorous methods of monitoring, evaluation, and impact measurement need to be established for these activities (and not just for crop improvement).

2.4. Training

The long-term training program at INTSORMIL has been continued to build the scientific capacity of professionals in Central America and Africa since 2006 through graduate study for advanced degrees and short-term training. From 2001-2007, at total of 116 students from 28 countries were enrolled through INTSORMIL in an advanced degree program, with 70% originating outside the US. From 2008, the numbers of long-term and short-term trainees have been stable at 40-46 and 10-11 respectively, with more than 70% of students from countries other than the US.

From 2008, compared to earlier years, food science has been the most heavily represented discipline, reflecting the emphasis of the grant on utilization. A number of agricultural economists have also been trained. Other disciplines included economics, entomology, pathology, plant breeding, agronomy, and

more recently, animal nutrition. This distribution departs from earlier periods, in which greater emphasis was placed on plant breeding. Over selected periods, sociology (1980-1989), physiology (1984-1994), and molecular biology (2000-2008) were also included (Heinrichs, personal communication).

Impacts of long-term training are summarized in the subsection about impacts. The quality of mentoring relationships is exceptional, as evidenced by a) continuation of professional relationships between PIs and host-country collaborators following degrees, b) other impacts cited above, c) quality of thesis work and exposure to practitioners while conducting real-world, applied research. One reason why is that scholarships offered through INTSORMIL enable much broader range of interaction with other disciplines and practitioners than is often the case in a US graduate program.

For example, Alexis completed his BSc at Zamorano in Honduras, coming to Purdue University after working for the national development bank in a lending program for smallholder farmers in his home country of Ecuador. He spent two summers learning about sorghum while conducting work for his MSc thesis in El Salvador, and presented his findings about value-addition in the sorghum industry in a regional meeting held at CENTA. There, he met not only other INTSORMIL investigators, but representatives from producer associations and government. These professional contacts, combined with what he has learned about international development, poverty reduction and technology transfer at graduate school, have led him to consider pursuing a PhD. Gabriel, from Bolivia, also began his studies at Zamorano. For his thesis on dual purpose sorghums, he interviewed representatives from various stakeholder groups, in addition to plant breeders and 120 farmers over a three month period in Nicaragua. He now recognizes the economic importance of sorghum, having learned its potential impact on the Nicaraguan dairy industry—and is considering working in the dairy industry in Bolivia. Bernadette, who was selected by the host-country collaborator in Zambia and attended Ohio State University, won the Department's award for her MSc thesis, which was conducted on the efficiency of sorghum production. Following his PhD, with a concept note developed during the regional meeting in West Africa that was convened by INTSORMIL, Moustapha obtained a grant from the McKnight Foundation to further his work in Niger on the incubator concept in small-scale sorghum and millet processing. He and his PhD advisor at Purdue University developed the approach. Vilma Ruth graduated with an MSc degree in Food Science from Texas A & M in 2008 and returned to CENTA to coordinate/conduct INTSORMIL research activities in Central America on sorghum grain quality and utilization. Her work has provided a foundation for the use of grain sorghum as a partial substitute for wheat flour importation in bakeries throughout El Salvador. In support of this work, she has developed sorghum milling protocols and facilitated the distribution of small CTI mills throughout El Salvador so that locally grown sorghum can be milled and used in the regions. Her INTSORMIL supported training made it possible for her to develop and provide this invaluable leadership for the program. These examples, out of many others that could be cited, illustrate the quality of mentoring provided by the PIs on the marketing and utilization projects at Purdue and Ohio State Universities.

Areas of concern: Successes such as these were achieved at low cost to USAID relative to benefits. Costs were borne largely by US PIs and universities who provided the time and in some cases waived tuition fees. The cost of training a graduate student in the US has absorbed a large share, if not all, of the annual direct costs allocated to a PI for a project (approximately $80,000 per year less the indirect costs

charged by the sub-contracted university in the US). A number of food science degrees have been conducted at the University of Pretoria. The EET recommends that INTSORMIL examine various alternative long-term training options in order to identify the most cost-effective strategy for long-term training. Short-term training is also of growing importance as the range of actors participating in agricultural innovation (research and development) systems in developing countries expands to include non-government organizations of various types, institutes, companies, and farmers' organizations in addition to universities and national agricultural research and extension systems.

2.5. Impacts

In 2010, as directed by USAID, INTSORMIL allocated funds to impacts analysis. Products included several MSc theses that evaluated the potential and actual impacts of research investments in germplasm improvement and value-addition, and an in-depth assessment of the impacts of long-term training. The products are of high research quality, and articles developed from the findings will be submitted to refereed journals. In addition, the way the work was executed suggests that the teams coordinated their efforts thoughtfully with other stakeholders, such as host-country collaborators and ICRISAT.

In a recent summary of progress in Mali and Niger, Sanders noted that despite the significant investments by US universities through INTSORMIL over the past three decades, "there has been a disproportionate advance in the research sector" alongside increasing challenges in collaborating with other stakeholders (sectors), and related to this, limited adoption of promising new technologies by farmers. In the project sites, Sanders and colleagues have analyzed the impacts of the technical package diffused through the Production-Marketing Project (Section 2.3) on farm yields, farm incomes, and the development of marketing cooperatives each year. Most recent results are reported by Coulibaly (2010) for southern Mali and Ibrahim et al. (2012) for Niger. In Niger, where work was funded by the McKnight Foundation, yields of improved sorghum (Sepon 82) and millet (Zatib) were low in 2010 for a number of reasons associated with the cropping season, seed quality, choice of site and soil type, and poor agronomic practices.

In Mali, research since 2005 shows clearly that with tied ridging, improved varieties, moderate amounts nitrogen and phosphorus (potassium is generally sufficient), and more cost-effective, high-analysis fertilizers, crop yields for the average farmer in a normal year are 40% higher than otherwise, with the best farmers reaching 2.5 tons to 3 tons per hectare (Coulibaly, 2010). However, to ensure relative profitability, in addition to reducing fertilizer costs, farmers must be able to sell clean grain at a price premium, store it for sale later in the season, and engage directly with end-users rather than intermediaries. When all of these aspects come together, returns are higher with sorghum than with cotton. Thus, in the region where this technology was introduced farmers call Grinkan (the new sorghum cultivar) the "cotton of Garasso" (Coulibaly, 2012).

Previous research by Sanders and colleagues, and ICRISAT, has repeatedly demonstrated high rates of return to research investments in sorghum and millet. Dalton and colleagues conducted a meta-analysis

and synthesis of this research, finding average rates of return of about 60 cents to every dollar invested, although returns varied significantly depending on the type of study, methods used, and location of study. They then conducted two country studies in Ethiopia and Sudan, where ICRISAT had not undertaken impacts analysis. The Sudan study indicates a combined annual economic benefit of USD 784 million, with large benefits from two recently released varieties (Tabat and Wed Ahmed) and cumulative benefits of Hageen Dura 1 (since 1983) that may justify the entire INTSORMIL project (Dalton and Crespi, nd).

A thesis by Jaeljattin Jaen Celada documents the potential returns to investing in sorghum products in El Salvador and Nicaragua, demonstrating that substituting sorghum for maize in livestock feed has a far greater potential to improve farm welfare than substituting sorghum flour for wheat. Increasing yield alone would actually reduce producer welfare—underscoring the fundamental motivation of INSORTMIL's work during this phase—which is the importance of stimulating demand for sorghum, millet and other minor grains through research and development of quality end-uses in the value chain.

Sanders led a three-day training course on measuring impacts to scientists in national agricultural research programs in Central America, and advised another two MSc theses about the impacts of dual-purpose sorghum cultivars (selling the grain and feeding the stalks) in the dairy sectors of El Salvador and Nicaragua. Despite rapid growth of intensive poultry production and dairy in Central America, use in poultry feed has been constrained by lobbies for low-cost maize imports and lack of recognition that non-tannin sorghums are nutritionally similar to maize and widely available in Central America. In most years wheat flour has a cost advantage over sorghum flour, although there has been some substitution of sorghum for wheat flour in bakery products. Finding greater potential for use of sorghum in the dairy industry, Sanders et al. measured benefits and their distribution among producers and consumers. In both Nicaragua and El Salvador, rates of return to investments in sorghum research were high. Emphasis on dual purpose cultivars meant that smaller producers benefitted more than larger producers, and total benefits to producers were greater than total benefits to consumers. In El Salvador, consumers gained more than large farmers. Thus, dual-purpose sorghum cultivars appear to increase both the efficiency and equity of resources.

Assessing impacts of training is central to INTSORMIL's primary mandate. Dalton and colleagues expanded and summarized the database maintained on 766 (77% of all) long-term trainees by the ME, and completed a bibliographic search by name to derive a measure of scientific productivity. They found that 8871 articles had been published since 1979 (over 32 years), in five major disciplines and five geographical regions. On average, scientists produced 11 academic documents. Aside from this evidence strong contribution to the advancement of science, the authors found no geographic concentration in authorship of publications and no evidence of differential performance between men and women.

Areas of concern: Additional impacts analysis of sorghum and millet plant breeding programs may not yield much in terms of new information, and especially information that is useful to INTSORMIL and USAID. However, INTSORMIL's work in the areas of marketing and utilization has yet not been adequately assessed. Annual evaluations of yield and income effects show year-to-year variation but not underlying causes, and effects are relative to target population but not to a control population.

2.6. Gender

The EET viewed gender –related considerations from the perspectives of: a) training; b) staff composition (ME and PIs); c) research and development activities. From 2001-2007, women represented 31% of long-term trainees, but this share grew to 45-48% in each years since 2008. Given the disciplinary emphasis of training on food science, this representation appears to be both equitable (representative of the disciplines) and equal (nearly 50%). Research by Beintema and Di Marcantonio (2009), who surveyed 125 agricultural research and higher education agencies in 15 Sub-Saharan African countries, shows that the proportion of women employed in food and nutritional sciences in Sub-Saharan Africa (44%) is substantially higher than in other disciplines. The proportion in agricultural economics is 24%, nearly 24% in entomology, and lower in agronomy, animal science and crop science. The authors also concluded that the gender gap in African agricultural sciences may be narrowing, especially in southern Africa, although *not* in West Africa and Ethiopia. Also, the shares of women enrolled in advanced agricultural education were higher than the share of women employed at research and higher education agencies. We are not aware of similar studies undertaken for Central American countries.

In terms of staff representation, only one of the US PIs, and few of the international PIs are women. This representation is, however, largely outside the control of INTSORMIL and is a reflection of the composition of university staff, those who respond to requests for proposals, and staff of in-country NARES. The administrative staff of the ME is women who are highly committed to their work and state that they have adequate professional opportunity.

With respect to research content, there is adequate recognition in project documentation of the importance of women as producers, consumers and in particular, small-scale processors of sorghum, millet, and other minor grains. Data presented in Chapter 5 of the Atlas of Sorghum: Production in Eastern and Southern Africa (Wortmann et al., 2009) suggest women family members contribution more than 50% of sorghum production in each country of Eastern and Southern Africa except Ethiopia and Rwanda, more than 50% of post-harvest handling in all countries of these regions, and over 50% of marketing in Kenya, Malawi, Mozambique, Uganda and Zimbabwe. Work with farmer's associations in the West Africa region by INTSORMIL has highlighted the fact that women are often allocated poorer fields that are farther from villages, lowering the expected benefit-cost ratio of the technical package that the program is promoting. The project has attempted to address this issue, but again, tenure-related cultural norms are outside the purview of INTSORMIL. Given the sparse budgets available to spend on engaging actors in the value chains, the emphasis on marketing and utilization since 2006 is more in form than in content. The opportunity to develop women's processing organizations in a systematic, coordinated way has not been feasible give the sparse budgets available to be spent on engaging actors. Reflecting this problem at a far more fundamental level, Jackson stated that "inconsistent record-keeping and miscommunication resulted in incomplete records relative to participation by women in stakeholder training and workshops. Greater diligence in record-keeping and re-emphasis of the need for such data collection is needed" (Annual Report, 2010: 109). The vision of regional coordinators and PIs appears to include this portion of the value chain, but resources and the

approach taken have so far been insufficient. In fact, a value chain analysis should be gender-differentiated at each node in the marketing chain from farmers to end-users.

The theses of Jeanne Coulibaly and Bernadette Chimai are noteworthy in this regard. Each tested gender-related hypotheses related to sorghum production and income. Jeanne (2011) found that the most profitable economic activity for Malian households was not the most beneficial for women. Removal of the fertilizer subsidy and the return of the cotton price to long-term trend led households to reinvest in sorghum, releasing labor and enabling women to invest in production on their own private plots and raise more income to support their children. She concluded that there is a need to focus on women's access to better land and inputs, reducing demands on their labor from the extended family household[6]. Bernadette found that female headed households were less technically efficient as sorghum producers, although their access to quality land, improved seed, and fertilizer is also known to be less.

Areas of concern: More systematic gender analysis is warranted in the areas of marketing and utilization, in the context of the value chain approach, at nodes of the value chain other than the farm.

2.7. Associate award example

The two associate awards provide examples of what can be achieved by INTSORMIL when additional funds are obtained. Additional funding of $1.25 mill/year from 2008-2012 has enabled the team to pilot test a technical package and marketing plan with selected farmers' associations, and then scale-up the diffusion of the package through other stakeholders. The approach spans much of the primary value chain for sorghum grain (linking on-farm production directly to processor markets via group sales). Market linkages to feed producers and commercial poultry farmers have not yet been fully exploited. The project has not yet resolved the institutional challenges of seed supply, and this is recognized by the project leadership.

Overall, the associate award has enabled INTSORMIL to address major supply chain/market development targets originally identified in the grant agreement, which would have been unattainable otherwise. The Mali project is now especially concerned with the management, delegation and training requirements of leading a national program as compared to a pilot. Encouraging transparency within farmer's organizations, concern with member incentives, and good relations with banks is a priority. Activities are expanding again in Niger and Senegal through other funding sources. Numbers of farmers' organizations have grown and the pilot structure now varies through the activities of Sasakawa 2000,

[6] Labor and land in agricultural households of Mali are organized under the leadership of a patriarch, including the families of his sons, his wives, and all of his unmarried daughters. They can extend to more than 70 members. Typically, women produce crops on land that is allocated to them, in addition to contributing to production of staple grain on family fields, in order to contribute the ingredients of the dishes consumed along with the staple grain.

AMEDD (Association Malienne d'Eveil a Developpement Durable-a regional Malian NGO), and of course, the national research system (IER and DRA).

In the case of Central America, INTSORMIL's proof of concept was accomplished in El Salvador and Nicaragua. The explicit objective was to develop brown midrib dual purpose (grain, forage) sorghum variety because of the importance of forage to smallholder farmers in this region. Brown Midrib (bmr) is the phenotypic coloration associated with lower lignin content and better digestibility of forage for livestock. The relatively small additional $1.1 million obtained through the Associate Award for Brown Midrib was sufficient to facilitate the expansion of the concept throughout Central America (Honduras, Panama, Guatemala) and Haiti, greatly increasing the potential impact of the scientific research. Fifteen lines were tested for local adaptation across the countries. As in the case of the Mali Associate Award, the Brown Midrib team is working with artisanal seed production for further dissemination, based on pre-existing farmers' organizations. Not all make a profit at seed multiplication. In Haiti, where there is virtually no formal seed industry, INTSORMIL is working with Catholic Relief Services, which has considerable experience in seed fairs, seed vouchers, and linking formal and informal seed systems.

In both cases, awards enabled INTSORMIL to better address the objectives of establishing partnerships and networks by engaging a wider range of stakeholders such as NGOs, farmers' associations, and professional associations of bakers and processors. Without these awards, much less would have been accomplished.

3. Partnership

3.1. Survey

In order to provide standardized information, the EET implemented a survey that was originally designed by team leader (Tim Dalton) of the Peanut CRSP evaluation, and adapted to sorghum and millet. The survey tool was managed electronically at Kansas State University and individual responses are confidential. The list of survey respondents was provided by the regional coordinators of INTSORMIL, and is shown in Annex Table 3. Survey results, as tabulated by the tool, are shown in Annex E. Here, we highlight only what we believe to be the most important findings.

First, the response rate of 49 out of 71 (69%) valid recipients (four addresses were incorrect, and six were redundant because they were secondary emails, and four were contacts but not INTSORMIL collaborators) is superb. A number of respondents contacted the EET by email to confirm that a response had been received. Respondents did not include current or recently graduated trainees (quoted in the section on training).

Second, over 84% of respondents focus on sorghum, underscoring the lack of research on millet and other minor crops. Nonetheless, only about a third reported that sorghum is "very important" in terms of production or consumption in their country. Importance in trade was generally low, as expected, and

the importance of millet as a crop was rated even lower. This confirms that the crops are often economically minor, but also that some prioritization is possible by country according to economic importance.

Third, about half of respondents reported that the financial contribution of INTSORMIL was important or very important in their research budget, which attests to the limitations of their budgets, and to how much a marginal dollar can mean in an underfunded research institution. Despite that fact, the funding covered about half to all the research costs of more than half the scientists. But this may be misleading: "the money received is at least sufficient to carry out a trial." However, one scientist remarks "until now, INTSORMIL intervenes in only 3 cercles (administrative zones) in the region of Mopti, Mali, and 12 out of 2040 villages. Marketing and utilization costs a lot, if it is to cover a significant scale, and most be borne by coalitions of actors rather than INTSORMIL funding alone.

Fourth, the modal response was that collaborators felt they had provided solid (average, equal, or more) input into setting research objectives, developing research methods to test hypotheses, and writing publications. Several comments are noteworthy in this regard, such as "my biggest disappointment is that we are not involved in INTSORMIL management and strategy meetings. I think this is very remiss and needs to be changed. It certainly is different in other CRSPs." In addition, "greater pooling of resources and knowledge in the region…" and "more interaction between the regional representatives and the collaborators in the setting and communication of overall research objectives and specific project goals may improve the coordination." A number of comments regarding financial management were also provided by respondents, and are included in Annex E.

3.2. Host-country site visit

3.2.1. Ethiopia visit

Two host countries- Ethiopia and Zambia were visited by one of the EET members. The visit to Melkassa Agricultural Research Center (MARC), Ethiopian Institute of Agricultural Research (EIAR) near the city of Nazreth and the headquarters of EIAR in Addis Ababa, Ethiopia were carried out on April 5-7 and the visit to Zambia was carried out on April 15-18, 2012.

SMOG CRSP researchers in Ethiopia work on improved variety development (breeding), soil, nutrient and water management, crop protection, food science and technology transfer, mainly on sorghum and peripherally on millet and teff. Almost all the senior and experienced researchers with PhD have left MARC for other jobs and for postgraduate studies. The current researchers are young recruits some of them with M.Sc. degrees. The names, qualifications and the addresses of these researchers with whom the meeting was held are presented in Annex D. The EET member also met two Directors (Drs. Adefris Chere and Tolossa Debele) of EIAR. According to the researchers, the combined use of agronomic practices such as tied ridge, skip rows and fertilizer has helped to increase grain yields of sorghum by 50%. However, these technologies are not disseminated to small scale farmers to bring impact owing to

insufficient funding. The researchers acknowledge that the work they are doing is jointly developed with the US partner (Dr. Wortmann) and their partnership is also effective. Their work is monitored by the US PI every year and through regular contact with e-mail. Their work is also reviewed every year through the national system. Their main concern is that there is an overall funding limitation from SMOG CRSP.

In the next phase of SMOG CRSP, the researchers would like to work in the areas of moisture and nutrient management to generate additional technologies. Crop management is very critical in the low rainfall dry areas where sorghum is growing. New varieties will be productive through moisture conservation and nutrient management. They also want to work on crop management practices of teff (*Eragrostis tef*), staple cereal crop of Ethiopia. The EET member was able to note that the different researchers are reporting and interacting with the US PIs directly, but horizontal interaction and cooperation among the SMOG team members at the host country level is weak. The team work at the host country level will also help to reduce expenses, say for example, having one workshop instead of workshops by different units working on SMOG.

Work on food science and value addition is weak. Research on malt sorghum was initiated for brewery industries, but discontinued owing to the departure of Dr. Senait Yetneberk. The Food Science Unit has not so far developed products with long shelf-life for the food market. Its work mainly focused on improvement at household consumption. It has trained households on the preparation of weaning food for children around 'Gelemso', Western Haraghe Zone, Eastern Ethiopia by adjusting the energy contribution from sorghum as the local food was less in energy for children. Around 200 farmers were trained how to maintain seed quality of sorghum for better income from the sale of grain. Sorghum grain quality going to the Ethiopian Commodity Exchange (ECX) is poor as a result of mixed varieties with different seed color and inert matter. The mixture contains both non-tannin and tannin sorghum grains. When farmers take non-mixed and pure grain sorghum to the market, price increases by 25-35%. Seeds of different varieties are mixed during planting and harvesting.

The Sorghum Breeding Program works on open pollinated, hybrid sorghum, drought tolerance (mainly through earliness) and introgression of striga resistance gene into local varieties. For hybrid sorghum development, lines come from Purdue University and ICRISAT and the first hybrid variety was released in 2008. Currently, two hybrid varieties that give 27-30% grain yield advantage as compared to check varieties are available in the country. Breeding for the control of striga has resulted in the development and release of three varieties (*Abshir*, *Gobiye* and *Birhan*). The breeding program has striga sick plots at 'Pawe', 'Kobo', 'Humera' and 'Fedis' locations in different parts of the country. Presently, the breeding effort is continuing to combine hybrid vigor and striga resistance. Work on drought tolerance has also resulted in the development of two early maturing varieties. The partnership with the US PI (Dr. Gebisa Ejeta) is strong and excellent. The breeding activities emanate from national need and strategy. There is frequent visit by the US PI to monitor activities in Ethiopia and interact with local partners. The researchers proudly appreciate the contribution of Purdue University in strengthening sorghum breeding in Ethiopia in capacity building and material supplies. They need research support to improve intermediate and highland sorghums. Because production of sorghum seed is not well addressed by private as well as government parastatal seed companies, the researchers would like to strengthen community based seed production by using small seed pack system to satisfy needs of small scale farmers and bring more impact. Overall, strengthening collaboration at host country level among sorghum value chain researchers in different institutions and agro-ecologies is of great importance.

Technology transfer in sorghum is weak and the approach needs to be revisited. More actors need to be part of the process for greater impact.

3.2.2. Zambia visit

In Zambia, the visit was made at Golden Valley Agricultural Research Trust (GART), Zambia Agricultural Research Institute (ZARI) and University of Zambia on April 15-18, 2012. Development of improved varieties (breeding), value addition and market development are the areas of SMOG handled by researchers in cooperation with US PIs. The sorghum breeding work is led by a senior scientist Dr. Medson Chisi, who is also Deputy Director of Research Services (all research stations) in ZARI. Dr. Chisi has been involved in INTSORMIL for a long time and also assists sorghum breeding in Southern Africa countries. The socioeconomics work on SMOG is led by Dr. Gelson Tembo and Mr. Moonga leads the food science work. The main focus of sorghum breeding is to shift sorghum from subsistence to commercial level and attain food security at the household level; develop hybrid varieties with quality traits. Sorghum is grown in marginal areas where maize does not do well. Specific areas addressed through breeding are a) enhancing genetic variability through germplasm collection and hybridization, b) work on stability of yield, c) development of open pollinated and hybrid varieties, d) address quality needs of end users, e) seed production of released varieties, and f) awareness creation on improved varieties via field days. Farmer participatory breeding is employed to develop farmer preferred varieties and other end users such as Zambia Breweries. The breeding program has released a number of varieties that include hybrid varieties in Zambia to satisfy the needs of different end users. The promising breeding materials developed in Zambia have also been released in other Southern Africa countries. For instance, six lines have been released in Mozambique recently. Seeds of improved varieties are produced in farmer's fields as government parastatals like ZAMSEED are not interested in producing sorghum seeds. NGOs working on crop diversification in the valleys and drier areas of Zambia contribute to training of farmers in seed production together with ZARI. Some of these NGOs are World Vision, FODIS (Food Crop Diversification Project), Harvest Help, Care International, OXFAM, WWF (World Wide Fund) and CRS. ZARI provides new batches of seeds every three years to minimize contamination of seeds in the hands of farmers. Extension officers from the Ministry of Agriculture also assist in educating farmers how to save produce as seed during harvest.

Dr. Chisi acknowledged that the sorghum breeding program wouldn't have been successful without INTSORMIL/SMOG support. Many research supplies like crossing bags are obtained from the US partner. SMOG also helped in covering operational expenses of trials, meetings with industries and other partners, in organizing field days, and acquiring research facilities. With respect to technology transfer, extension institutions are very slow in promoting sorghum and millets although the government has put crop diversification in its 5^{th} and 6^{th} national development plan. Lack of seeds of improved varieties and awareness were problems in technology transfer. Farmer's cooperatives are formed to contribute to technology transfer. Insufficient funding under SMOG CRSP was mentioned as one constraint in pursuing research and development work on sorghum as compared to the earlier INTSORMIL times.

Researchers from the University of Zambia (UNZA) handle value addition and food science components of the value chain. Dr. Tembo, who is leading the market study at UNZA expressed that the partnership with US PI's (Drs. Mark Erbaugh and Donald Larson) works well. He, however, mentioned that there was budget limitation for carrying out surveys by taking more samples and areas. Collaboration of UNZA researchers with the US PIs is strong, but there is no collaboration with the breeders at GART/ZARI within Zambia. The food science component is led by Mr. Moonga. The work started by doing a survey

to understand the problem. Quality of sorghum grain for market was poor due to mixed seeds and inert materials and hence getting good quality seed for processors has been a problem. Under SMOG CRSP, there is a PhD student at the University Nebraska (about to complete study) and another student is working in the University of Pretoria, South Africa.

Generally, there is a need for SMOG CRSP at the host country level to be multidisciplinary along the value chain of SMOG CRSP crops. More collaboration and interaction is necessary as researchers from different institutions are addressing components of the same value chain of a crop. Detailed report on the site visit in Ethiopia and Zambia is given in Annex D.

4. Administrative Review

4.1. Program management

The ME states its mission as follows: "The mission of the INTSORMIL Management Entity is to facilitate the Financial, Leadership, Public Relations, Coordination, Reporting, Liaison, and Communication aspects of INTSORMIL. With its leadership the Management Entity disseminates the information among USAID Washington, the Host Country scientists in Africa and Central America, and the scientists related to INTSORMIL. The ME searches opportunities for related Associate Awards and new projects that will further the mission of the core projects. The ME provides the scope of work and will make decisions as to which projects will be funded. The ME uses competitive processes when awarding project funds."

The ME has been challenged to adjust to changes in USAID that affect implementation of SMOG contracts. One example mentioned by the ME is the need to align with FtF objectives midway in their contract period. The budget reduction in 2006 as compared to previous years has been another issue to address. This brought reduction in project budgets to PIs and delay in some activities such as training, research and technology transfer. In terms of collaboration, the ME works with US universities in developing and conducting specific projects and the PIs collaborate with other US scientists, NARS, NGOs, private sector, international agencies, CGIAR centers and other projects in the regions. The INTSORMIL program has contributed immensely to human capacity building and institutional strengthening that resulted in strong national sorghum improvement programs. Sub-awardees collaborated with each other and with the relevant stakeholders in regions and host country level and form networks to leverage funds for technology transfer. The ME has been using the technical advisory committee to annually review activities and work plans. The ME examines annual work plans submitted by the PIs using the technical advisory committee. However, it is not clear how the ME is monitoring each research activity considering the large number of activities in the project. The ME uses participatory decision making where all PIs are allowed to call and interact with ME staff in respect to their requests, suggestions on improvements and other needs. The ME needs to be strengthened in following up research and development activities of SMOG through a panel of technical committee that represent different disciplines. Management problems are resolved through discussion with the Program Director.

The structure of the program is shown in Annex F. Missing from this structure are the Board of Directors and the Advisory Committee. Until 2006, INTSORMAL had a Technical Committee (TC) that met annually. The TC included a representative from each discipline of study, all regional coordinators, and a USAID representative. TC members were elected but rotated in membership, and included host-country collaborators. The TC was responsible for reviewing project performance and in cases where decisions had to be made regarding continuation, for example, the TC made a recommendation to the Board of Directors. At that time, the number of INTSORMIL PIs was much greater (31). USAID recommended discontinuation of the TC in 2006. When some funding was restored for specific activities in 2009, the ME gradually reinstated an Advisory Committee, which has met two or three times, but has a much broader membership than did the TC, and as yet, no stated terms of reference.

The Board of Directors is regarded as the top administrative guidance committee. The ME reports to the Board regarding work plans and budgets, and the Board must approve recommendations before these are put into effect. Board membership is a service position. One meeting is convened per year, and conference calls are used when other decisions must be made.

Dr. Yohe reports that over the years, the ME was not permitted to solicit funding from USAID Missions, but in some years, PIs have submitted proposals to foundations, such as the McKnight Foundation. Responding to USAID has proven to be very time-consuming. International meetings were held every five years, but the last meeting was in 2002 in Ethiopia. There has never been a budget for communications, although Kim and Short have both worked on these aspects, with an intern, Tony.

4.2. Financial management

The Year 6 budget was provided to the EET as an example, to illustrate the structure of funding. The structure is clear and transparent. Management staff time allocated to INTSORMIL, including indirect costs of 44.9%, totaled less than 20% of the total. When ME operating costs, the meeting of the Advisory Committee, Board and CRSP Council are included, the share of the ME and operations is 25% of all costs. This does not appear to be too high. On the contrary, it was clear to the EET that few, dedicated staff accomplish many tasks and fulfill multiple roles.

Half of the total funds are allocated across the individual projects, to lead PIs and their universities. Only UNL applies an indirect cost to their share, although partner universities may or may not apply their own indirect costs. When PIs then authorize payments to host-country collaborators, institutions of host-country collaborators charge their own indirect costs. Thus, the funds actually transferred for research are extremely small, and enough to finance a trial, a small survey, or a national workshop.

Regional project funds are allocated by the regional coordinators (US and Host-Country) according to an assessment of needs and priorities, and these can be utilized to fund new initiatives that were not originally planned, take advantage of important opportunities, or resolve a problem. Among regional budgets, the largest regional share is allocated to West Africa (38%), followed by Southern Africa (25%),

Eastern Africa (19%) and Central America (17%). On these budgets, indirect costs are only charged on administrative costs.

With respect to financial management, by far the greatest constraint involves delay of approval and receipt of funds from USAID. For example, no funds have been received for 2012, which means that no work has yet been implemented in the field.

4.3. Monitoring and evaluation

As currently designed, the ME is responsible for monitoring and evaluation of projects. Based on discussions with USAID, the INTSORMIL ME developed a table with seven objectives, reproduced shown below:

Table 1. Objectives, notional targets, benchmarks and indicators, throughputs, and milestones

Objectives	Targets	Benchmarks and Indicators	Throughputs	Milestones
1. Supply chain/market development	- Increased yields and incomes - Increased pearl millet quality -Increased use of sorghum as a feed source	- Increased farmer incomes - Increase in production area - Elimination of tannin in feed–type cultivars	- Farmer incomes increased by 30% - Farmer incomes increased by 20% - 200% increase in markets for sorghum as a feed source	- 15% increase by Yr 3 and 30% by Yr 5 - 5% increase by Yr 3 and 20% by Yr 5 - 60% increase by Yr 3 and 200% by Yr 5
2. Nutrition, health and grain quality	-Higher grain quality cultivars -New cultivar acceptance - Increased nutrition of food and feed products	- High digestibility cultivars selected - Widespread adoption of cultivars - High starch digestibility cultivars developed	- 10 high grain quality varieties developed - 60% of farmers accept new cultivars - Nutritional deficiencies in diets decreased by 25%	- 4 varieties released by Yr 3 and 10 by Yr 5 - 20% of farmers accept new cultivars by Yr 3 and 60% by Yr 5 - 10% decrease by Yr 3 and 25% by Yr 5
3. ICSM	- Increased and stable grain yields - Improved crop, soil and water management	-ICSM components identified - Integration of ICSM components into packages	- 30% yield increase due to ICSM adoption - 70% of farmers using ICSM practices	- 10% increase by Yr 3 and 30% by Yr 5 - 25% using ICSM practices by Yr 3 and 70% by Yr 5
4. IPM	-Increased grain quality - Efficient pest management tactics -Reduced pesticide use	- Tolerance to grain insects, pathogens - IPM packages developed - Non-pesticidal strategies developed	- 20% decrease in insect-damaged grain - 4 varieties with insect resistance released - 50% decrease in kg pesticide used/ha	- 5% decrease by Yr 4 and 20% by Yr 5 - 1 variety released by Yr 3 and 4 released by Yr 5 - 20% decrease by Yr 3 and 50% by Yr 5
5. Genetic enhancement	-Stable yielding genotypes -More efficient water use by genotypes -More efficient nutrient use by genotypes	- Genotypes with less variation in yields - Decrease in drought damage - Savings in fertilizer costs	- 6 stable yielding genotypes released - 10 drought tolerant genotypes released - 4 N efficient genotypes released	- 2 genotypes released by Yr 3 and 6 by Yr 5 - 4 genotypes released by Yr 3 and 10 by Yr 5 - 1 genotype released by Yr 3 and 4 by Yr 5
6. Genetic resources and biodiversity	-Higher yielding genotypes -Conservation of genetic biodiversity	- Selection of high yielding genotypes - Decrease in rate of loss of biodiversity sensitive areas	- 25% increase in yield of new genotypes - 20% decrease in use of biodiversity sensitive areas due to increased yields	- 10% increase in yield by Yr 3 and 25% by Yr 5 -5% decrease in use of biodiversity sensitive areas by Yr 3 and 20% by Yr 5
7. Partnerships and networking	- Increased joint programs with partners	- Networks established involving all stakeholders (private industry, NGOs, farmers,	- High research throughputs and high level of technology transfer activity	- 20% increase in grain production and 75% of farmers using best management practices by Yr 5

In reviewing this table, the EET was particularly struck by the throughputs and milestones associated with objectives 1, 2, 3, 6 and 7, especially relative to the size of the budget, the scope of activities, and their structure on a project-by-project ($80,000 per year) basis. Beginning with the objective of supply chain/market development, targets may have been reached to some extent. We have evidence of increased yields, production and net revenues from sorghum and millet in some years and sites in West Africa through the Production-Marketing Project and Mali Associate Award. However, many factors

other than this project affect overall farm incomes, and INTSORMIL funded only the pilot or "proof of concept" in the project. Thus, attributing any increase in farmer income to the activities of INTSORMIL during this time period would be problematic, even within project sites. Outside of project sites, it would be a fallacy. Similar points are relevant with respect to the second objective on nutrition, health and grain quality. That is, although the targets and benchmarks make sense, the throughputs and milestones related to nutritional status are entirely unrealistic. Also, adoption rates and declines in biodiversity-sensitive areas cannot be attributed to INTSORMIL, and are exceedingly difficult to measure even in specific project sites. There is, as a consequence, little evidence to support that these milestones were reached.

A final point is that extensive work is required to respond to the continual requests from USAID for information, some of which is used in USAID's own internal evaluation process, or to present each year to Congress. This work is generated outside INTSORMIL and is not foreseen in the project budget or work plan, but absorbs scarce resources that could otherwise be spent on other M and E activities, and internal reviews such as those previously accomplished by the TC crucial, internally-motivated evaluations. Detailed responses of the ME to the SOW questions are shown in Annex C.

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6. Annexes (attached as separate files)

Annex A. List of publication of INTSORMIL for the period 2006-2012

Annex B. INTSORMIL milestones achieved 2006-2012

Annex C. Responses of ME to SOW questions

Annex D. Report of host-country visit

Annex E. Survey of INTSORMIL host-country collaborators

Annex F. Organization of INTSORMIL

Annex G. Statement of work

Annex H.1. PPT presentation of Central America Region – Rooney

Annex H.2. PPT presentation of East Africa Region – Wortmann

Annex H.3. PPT presentation of Southern Africa Region – Peterson

Annex H.4. PPT presentation of West Africa Region – Hamaker

Annex Table 1. Crop management technologies of INTSORMIL: 2006-2012

Annex Table 2. Crop varieties released under INTSORMIL: 2006-2012

Annex Table 3. List of persons contacted

USAID
FROM THE AMERICAN PEOPLE

INTSORMIL PUBLICATIONS 2006-2012

Ejeta, Gebisa

Purdue University

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USDA - Georgia

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Annex B. Milestones achieved by INTSORMIL/SMOG during 2006-2012.

INTSORMIL MILESTONES Achieved 2006-2012

INTSORMIL Program (several PIs)

Objective 5: Genetic enhancement

- Eight drought tolerant sorghum genotypes released
- Two N efficient sorghum genotypes released (28% increase in yield with N)
- One highly resistant insect resistant (Sorghum midge in Niger) genotype released
- Two millet and one sorghum genotype with tolerance to disease released
- One bird tolerant millet and sorghum genotype released
- One poultry feed-type sorghum genotype released
- Fifteen human food-type sorghum genotypes released
- Eleven forage-type sorghum genotypes released

Gary Peterson

Objectives: IPM, Genetic Enhancement, Genetic Resources and Biodiversity:

- Three lines from the sorghum midge (*Stenodiplosis sorghicola* Coquillett) resistance breeding program are in advanced yield testing in Mozambique for possible release as varieties

- Fifteen lines developed from the sugarcane aphid (*Melanaphis sacchari* Zehnter) resistance breeding program are ready for advanced testing for grain yield and adaptation. Each line has excellent resistance to sugarcane aphid and several have excellent resistance to anthracnose

Objectives: Genetic Enhancement, Genetic Resources and Biodiversity:

- Three lines from the drought breeding program are in advanced yield testing in Mozambique for possible release as varieties

- Inbred parental lines in development will produce hybrids will increased grain yield versus standard checks

Objectives: Nutrition, health and grain quality:

- Lines with lemon yellow pericarp and tan plant have been identified with enhanced levels of the flavonones eriodictyol and naringenin, compounds with potential benefit as nutraceuticals. Research is on-going improve the resistance to grain weathering, and to identify and sterilize suitable seed parents for hybrid seed production

- Sureno is in advanced yield testing in Mozambique for possible release as a variety

John Sanders

Objective: Supply chain/market development

- Net income/ha was increased by 30% in 2008 for the Garasso (Mali) farmers' association of 50 members.

Note: Increased sorghum yields and incomes. We increased yields by 50 to 100% and prices by 20 to 50% where farmers followed our recommendations and the weather conditions were good or normal. Given all that on a per ha basis for sorghum in Garasso with traditional yields at 1,000 kg/ha, we increased them to 1,500 kg/ha in 2008. Price at harvest was 100 cfa/kg and our farmers sold for 120 cfa/kg. Then income from sorghum on this one ha is increased from 100,000 cfa/ha to 180,000 cfa/ha with added costs of 50,000 cfa/ha.

- For 2009 in Garasso we had a 50% increase in income/ha for a farmers' association of 150 members.

Note: In 2009 we had mean yields of 1.9 t/ha in Garssao and a price of 105 cfa/kg (compared to non- program yields of 1 t/h and a price received of 100 cfa/kg) /ha with 50,000 cfa/ha as additional costs

- On the basis of these Garasso results USAID-Mali financed us and IICEM to do a large scaling up of this technology-marketing-farmers' association project over the period 2010-2012.

- In the Mopti (Mali) region extended millet technologies over the period 2009-2012. Income increases were 15 to 30%. Construction of storage facilities was completed in seven villages. 300 to 500 ha of new area in these technologies were added in 2010 and 2011 and another 500 ha is programmed for 2012.

- Expanded program from Mali to Niger and Burkina in 2010 and in 2011 to Senegal.

Larson/Erbaugh

Objective 1: Supply chains/Market development

- Low farm incomes; most households have multiple sources of income;
- Low productivity & very little use of improved practices including purchased inputs;
- No productivity gains in last 25 years;
- Shelf ready technology not adopted;
- **Smallholders need market incentives to adopt new technology;**
- **Smallholders who applied recommended technology package (improved seed, fertilizer, & agronomic practices) increased sorghum yields by 46 percent.**
- **Sorghum sold increased by 67 percent.**
- **The same smallholder farm incomes increased by 14 percent.**
- Processors benefit from more stable & increased sorghum supplies

Objective: Capacity Building

- Support for M.S. degree training at OSU in AED Economics for one student from Tanzania and one from Zambia;
- PhD support for one faculty member from SUA in the SUA PhD program;
- Support for three M.S. students in agricultural economics at SUA;
- Support for three senior research projects at UNZA;
- Valuable research and publication experience gained for collaborating faculty and students. With collaborators made at least 7 presentations and published over 10 articles and papers.

Mitch Tuinstra

Objective 2: Nutrition, health and grain quality

- Transfer of >250 food-grade sorghum breeding lines and populations to IAR in Nigeria and INRAN in Niger
- 4 parent lines or varieties released by Yr 5

Objective 3: IPM

- Identification and pre-commercialization of herbicide seed treatment/cultivar technology packages that maximize grain yield of hybrids for the malting industries in Nigeria through public-private activities with full commercialization of public varieties and herbicides in the next 2-3 years
- ISM (Integrated Striga Management) packages for guinea and non-guinea sorghum producing regions

Objective 5: Genetic enhancement

- Public release of 31 sorghum parent lines (PU-KS 1 to PU-KS 31)
- 6 genotypes released by Yr 5

Objective 6: Genetic resources and biodiversity

- The sorghum diversity panel (300 accessions) was characterized at the genomic/genetic/phenotype level for variation in stable dwarfing genes, cyanogenic glucoside production, and floral architecture traits
- Phenological and agronomic characterization of core sorghum collection

Objective: Partnerships and networking

- Effective public-private sector partnerships have been developed with Dupont Crop Protection and Pioneer Hi-Bred to facilitate commercialization of herbicide seed treatment technologies in West Africa in collaboration with NARs in Mali, Burkina Faso, Niger, and Nigeria
- Increased private investment in sorghum research and commercialization in Africa

Bill Rooney

Objective 2; Nutrition, health and grain quality

- Six varieties released by Yr 5
- bmr forage quality increased by 10%
- Use of bmr forage increased by 10%

Objective 5: Genetic enhancement

- Six varieties released by Yr 5

Objective 6: Genetic resources and biodiversity

- 10% increase of area in bmr varieties

Vara Prasad

Objective 3: ICSM

- Microdose of fertilizer application increased millet yields > 50% in Burkina, Niger and Mali
- Application of 20 kg P and 30 kg N significantly increased millet yields in Niger
- Use of Mechanized zai + compost increased millet yields > 50% in Burkina
- Application of 26 kg P increased sorghum yields in Ghana and Niger by > 50%
- Application of 90 kg N increased yields of sorghum by > 100% in Ghana and Niger
- ACN (contour ridges) increased sorghum yields by >30% in Mali
- NuMass model based fertilizer recommendation increased sorghum yields by >30% in Mali
- Increased plant population (50,000 plants ha^{-1}) and decreased spacing increased décrue sorghum yields by > 50% in Mali
- Traditional and early maturing genotypes (Saba soto and Saba tienda) provide greater yield stability in décrue sorghum in Mali
- Use of seed treatment with insecticide help controlling seedling pest and increased grain yield by >15% in décrue sorghum in Mali
- Improved genotypes (Kapala / Dorodo) provide increased yields of > 100% in Ghana
- Improved genotype (S0 x SAT) provide increased millet yields of > 60% in Mali
- Crop rotations showed significant benefits in long term compared to continuous cropping
- Phenotyped several grain sorghum germplasm collection in US for traits associated with drought tolerance. These inbred lines will be useful in programs in West Africa.
- Phenotyped several sweet sorghum germplasm collection in US for traits associated with increase d brix and sugars yields that can be useful in West Africa
- Trained three PhD students and three MS students from Mali, Ghana and Kenya on aspects related to ICSM.
- Four technicians in four countries (Mali, Ghana, Burkina and Niger) were trained as aspects related to ICSM
- During this phase about 400 farmers participated in field days or workshops as aspects related to ICSM in four countries.

Bonnie Pendleton

Objective	
4. IPM	➢ Resistance of mites was monitored and workshops held to teach farmers to use less miticide on the Texas High Plains.
	➢ Seasonal dynamics of southwestern corn borer was evaluated and a prediction model developed for farmers in Texas.
	➢ Fitness and loss of biomass by yellow sugarcane aphid were determined on sorghum.
	➢ A *Desmodium* grass trap crop was evaluated and found to protect sorghum and pearl millet against stalk borers in farmers' fields in Mali, Mozambique, and Niger.
	➢ Resistant seed and a leaflet were produced to manage panicle bugs in farmers' fields in Mali.
	➢ Storage insects, grain conditions at harvest, storage facilities, and storage methods were surveyed and posters prepared, workshops held, and media releases used to train hundreds of farmers, crop protection personnel, and extension to identify and manage pests of sorghum and millet in Mali and Niger.
5.Genetic enhancement	➢ Effect of photoperiod on greenbug biotypes was determined to better evaluate sorghums for more sustainable resistance.
	➢ Two hundred seventy-five sorghum lines developed for resistance to greenbug biotypes E and I were evaluated each year for private seed companies in the US.
	➢ Sorghum lines resistant to aphids and stalk borers were evaluated in southern Africa.
	➢ Sorghum resistance to insect and disease pests was evaluated at Nampula Station and in fields of 360 farmers in Nampula and Cabo Delgado provinces in Mozambique.
	➢ Seed of Macia and Sima sorghum was multiplied at Nampula Station and by 240 farmers for distribution to other farmers in Mozambique.
	➢ Seed were evaluated and multiplication and release assisted for three sorghum midge-resistant varieties that were readily adopted by farmers in villages in multiple regions of Niger.
	➢ Resistance to storage pests was determined for the sorghum lines in the Mozambique breeding program.
	➢ Sorghum genotypes were evaluated and causes determined for resistance to maize weevil in the US and Mozambique.
	➢ Pearl millet genotypes resistant to millet head miner were produced in Niger.
7.Partnerships and networking	➢ One Ethiopia Ph.D., 3 Mali M.S., 2 US M.S., 1 US B.S., and 6 Niger intern students were educated for 100% greater capacity.
	➢ Four technicians and 4 scientists from Mali, Mozambique, and Niger

	gained improved research capability and knowledge of new IPM technologies through training and on-site visits.
	➢ Hundreds of farmers in Mali, Niger, and Mozambique participated in workshops and field demonstrations to learn to manage pests of sorghum and millet.
	➢ Partnerships were developed with such NGOs as World Vision, Save the Children, Care, etc. to distribute sorghum seed to poor farm families in Mozambique, Mali, and Niger.
Note: With less need for insecticide because of development of resistant sorghum and millet genotypes and better pest management strategies, the Entomology Project also is linked to helping improve "Supply chain/market development" and "Nutrition, health and grain quality."	

David Jackson

Objective 2: Nutrition, health and grain quality

- Increase nutrition of Food products…actual development of food products by women's groups / w sales to community…increases income

Objective 7: Partnerships and networking

- Involvement with Tanzanian Food and Nutrition Center, training of women's groups, resulting in income increases, networking with farmers, government (TFNC)…helps pull product through market.

Objective 2: Increase nutrition of Food products

- Actual development of food products by women's groups / w sales to community increases income

Objective 7: Partnerships and networking

- One MS student graduated…now working on our program at the Tanzanian Food and Nutrition Center,
- One PhD student will be finished by the end of the grant.

John Leslie

Objective 2: Nutrition, health and grain quality

- Identification of *F. verticillioides*, a potent producer of fumonisins, from finger millet grain
- Identification of two new *Fusarium* species from sorghum and millets
- Tested strains of *Fusarium* from sorghum, pearl millet and finger millet for their ability to produce beauvericins, fumonisins and moniliformin
- In an on-farm trial conducted with IITA, showed that Maize >>Sorghum>Pearl millet in terms of aflatoxin contamination

Objective 4: IPM

- Identification of *F. verticillioides*, a potent producer of fumonisins, from finger millet grain
- Identification of two new *Fusarium* species from sorghum and millets
- Identification of 2500+ *Fusarium* isolates using morphological and molecular characters
- Identification of two new mating populations (sexual stages)

Objective 7: Partnerships and networking

- *Fusarium* Laboratory workshops held every year: 2007, 2009 & 2011 – Kansas State University, Manhattan; 2008 – Science University of Malaysia, Penang; 2010 – National University of Rio Cuarto, Rio Cuarto, Argentina; 2012 – University of Bari, Bari, Italy; 2014 – Seoul National University, Seoul, Korea; 2016 – University of Pretoria, Pretoria, South Africa
- Tropical *Fusarium* workshops: 2009 – Recife University, Recife, Brazil; 2012 – Lavras University, Lavras, Brazil
- Scientific Writing Workshops: Science University of Malaysia (2008, 2010 & 2012 – 250 total participants), Seoul National University (2007, 2008, 2009 & 2011 – 180 total participants); Kansas State University (2009, 2010 & 2011 – 350 total participants); BOKU, Vienna, Austria (2011 – 40 participants); American Society for Microbiology (2010 & 2011 – 80 total participants); University of Pretoria (2007, 2008 & 2010 – 150 total participants); National University of Rio Cuarto (2010 – 180 participants); University of Malawi (2009 – 20 participants); ZARI, Lusaka, Zambia (2010 & 2009 – 60 total participants); Recife University (2009 – 100 participants); University of Lavras (2009 – 80 participants); Korean Society for Microbiology (2009 – 200 participants); Medical Research Council (2008 – 60 participants); Dalian National University, Dalian, China (2007 – 35 participants)
- Four graduate students (Korea – completed Ph.D. 2007; Malaysia – completing Ph.D. 2014, Mexico – completed M.S. 2012, and South Africa – completing Ph.D. 2015)
- Visiting scholars – Fulbright Scholar (Croatia – 2009-2010); Postdoctoral researcher (Egypt – 2007-2011); Borlaug Fellows (Malawi & Zambia – 2008); Turkish National Scholar (2008); Sabbatical visitor (Argentina – 2008)
- Incorporated sorghums and millets into the EU 7th Framework program

C. Wortmann

Objective 3: ICSM

- Fertilizer rates developed for Ugandan sorghum
- Reduced tillage recommendations for sorghum in Uganda
- Skip-row planting technology for sorghum in Ethiopia
- Fertilizer recommendations for sorghum in Uganda refined
- Three sorghum varieties (2 hybrids) released in Ethiopia
- Fertilizer optimizer for sorghum released in Uganda

L. Rooney

Objective 2: Nutrition, health and grain

- White tan plant sorghums produce popular foods that are profitable and generate income for farmers and processors in CA.
- 20 food products were developed using sorghum in CA.
- The combination of hammer milling followed by attrition milling produces excellent flour in CA.
- Plate mills distributed among different processors were effective.
- Sorghums with high levels of unique healthy phytochemicals were identified.
- Special sorghums are effective as natural colorants with high levels of antioxidants and flavanoids that have anticancer activity.
- Sorghum produces a wide array of different natural colored products with excellent properties for healthy gluten free foods.

Objective 7: Partnerships and networking

- Ms Vilma Calderon and colleagues in the CENTA Food Technology Lab conducted 51 workshops with 1162 participants.
- Many participants of workshops use the CENTA developed technology. Profits are made and expansion continues.

Annex C. ME response to questions of the Scope of Work for the review of SMOG/INTSORMIL CRSP.

Response to Questions in the Scope of Work for the Review of the INTSORML CRSP, May 7-9, 2012, University of Nebraska, Lincoln, NE

I. Technical Review

A. Scientific/Technical Leadership

1. What are examples of scientific/technical leadership displayed by the ME?

1**. Proposal development: Award for core program and associate awards.**
2. RFA development
3 FtF Guide to PIs for workplan development
4. Review of annual reports

2. What are examples of scientific technical leadership displayed by the individual project Principle Investigators (PIs)?

Development of grant proposals in response to RFAs from INTSORMIL
Development of workplans
Peer reviewed publications
Mentorship of students
Competitive grants won other than INTSORMIL.
Successful networking

3. How are the separate research activities integrated into a broader strategy or thematic programming areas responsive to Feed the Future?

Results of individual US PI research projects are integrated in the regional research programs to develop and promote integrated crop management strategies to meet FtF objectives.

The ME participated in meetings sponsored by USAID on the FtF Initiative so we are well versed on the goals and objectives of the FtF Initiative. We developed a guide which describes the FtF Initiative and the details required for work plans to be in compliance with the FtF Intitiative. The guide was sent to PIs with the request for annual workplans.

4. How does the ME facilitate engagement of the research activities or themes with other development programs in regions where the CRSP is active?

Through extensive networking. Our PIs have been very effective in developing partnerships with other research organizations to increase the effectiveness of our research program and by developing partnerships with technology transfer oragnizations such as NGOs. We employ this approach to scale up our activities and thus to increase the impact of the INTSORMIL Program. We are constantly looking for partners to leverage and scale up.

5. How well has the ME facilitated the participation of new partners? Give examples of how program RFA/RFPs are designed and how opportunities are advertised and made available for new PIs.

This is a competitive process. First, INTSORMIL develops a proposal USAID in response to an RFA advertised by USAID.
Second, the proposal is submitted to USAID by the UNL Office of Research.
Third, if our proposal is selected as the winner of the competition USAID will request that UNL revise the proposal based on the criteria which they provide.
Fourth, the revised proposal is submitted to USAID, reviewed by USAID and then returned to UNL as a contract.
Fifth, using the contract as a guide RFAs for individual PI projects are developed by the ME and widely advertised over the web and announcements are placed on the web and sent to Land Grant University and other appropriate universities throughout the USA. An instructional sheet for developing a project proposal; and a Guide for aligning projects with the FtF initiative is included in the announcement.
Sixth, the submitted proposals are submitted to the ME, reviewed by the ME and if it meets the required criteria it is submitted by the ME to an external evaluation panel for review.
Seventh, the review panel informs the ME of the winners of each project.
Eighth, the ME again reviews the proposal and submits it to the winner for revision based on the comments of the external evaluators and those of the ME and given a date when the proposal is due back in the ME.
Ninth, the winner submits the revised proposal to the ME.
Tenth, the ME reviews the proposal and if it meets ME approval the ME requests that the winner submit a one year work plan.
Eleventh, the work plan is submitted to the ME, reviewed by the ME and if it meets the required criteria the ME develops an MOU with PI's institution.
Twelfth, the MOU is sent to the PIs sponsored program for signatures, returned to UNL a signed by a UNL College of Agriculture Dean and the Office of Research.
Thirteenth, the signed MOU is returned to the INTSORMIL ME and a financial agreement is sent to the PIs institution.
Fourteenth, the signed financial agreement is returned to the ME.
Fifteenth, the ME completes a form for payment which is submitted first to the College of Agriculture Dean and then forwarded to UNL sponsored program.
Sixteenth, the Year 1 payment is sent to the PIs institution. At the end of Year1 when the ME receives 50% or more of the receipts from the partner institution are received the grantee is eligible to review the second years funding. Then steps 11 through 16 are repeated.

6. Are the levels of effort, award size and research project duration sufficiently balanced to allow the CRSP to achieve program goals and objectives?

Award amount is insufficient to meet the research, technology transfer and training components as requested by USAID.
Award duration of five years is too short to conduct long term research and sometimes too short to complete training programs (especially when trainees start their program in the second or third year of a 5 year contract with USAID.

7. What have been the significant accomplishments in terms of research, outreach, and dissemination?

Selected accomplishments are listed below:

Networking:

- **Engaged 17 U.S. scientists at 6 U.S. universities and the USDA/ARS and 140 partners in Africa (14 countries), Central America (6 countries) and Haiti.**

Institutional capacity building:

- **Supported degree training of 948 students (46 for B.S., 458 for M.S. and 444 for Ph.D. and 28 % were women) in the USA and developing countries.**

100% of fully supported INTSORMIL students returned to employment with national programs.

- **CRSP model provides for continued mentorship for returning students and most continue to collaborate with their U.S. mentor through the INTSORMIL program. This approach has resulted in the development of strong national research and technology transfer programs in African and Central American countries including the Feed the Future (FtF) countries; Ethiopia, Mali, Mozambique, Nicaragua, Tanzania, Uganda and Zambia.**

Scientific productivity:

- **8,700 articles and academic materials published by 766 international and US scientists in five geographical regions (Africa=2,922; Asia and Near East=1,447; US= 2,700; Central and South America= 1,427 and Europe= 204). These documents were cited 68,015 times in the literature.**

Technology development:

- **> 2,200 sorghum and 350 pearl millet breeding lines released for use as donors in breeding programs.**
- **> 100 sorghum varieties released for commercial production in 20 countries.**
- **Estimated that 50% sorghum grown in the U.S. contains germplasm from INTSORMIL-affiliated university research programs with a value of $357 million of U.S. grain production annually.**
- **Since INTSORMIL began operations in 1979 sorghum yields have increased by 10.2 % annually which is an annual $71.5 million.**
- **In Sudan approximately $784 million in annual benefits from the sorghum improvement program with several varieties produced through collaboration with INTSORMIL.**
- **Malian collaborating farmers increased sorghum yields by 8.8 tons or 61% on poor land.**

Impacts:

- **Nigerien farmers achieved a two-fold increase in sorghum yields using the INTSORMIL inputs.**
- **Breeding for abiotic and biotic stress resistance has paid huge dividends: (1) Greenbug resistance is estimated at a net welfare gain to U.S. of $389 million, (2) Sorghum midge resistance a $9.90 yield gain per $1 spent on R &D, (3) Drought resistant hybrids produce 4,060 kg/ha under drought stress vs. 2,289 kg/ha for non-drought tolerant varieties and (4) In Niger, soil nutrient management practices increase pearl millet production by more than 500 kg/ha in both normal and dry years.**
- **A study on the importance of value-added products made from sorghum conducted in El Salvador and Nicaragua indicated that the biggest payout for research resources currently**

(2012) is in the development of markets for using *bmr* sorghum as livestock feed (forage and grain for dairy cows and poultry) and for food sorghum as a partial replacement for wheat in the baking industry. Both are INTSORMIL activities.

- **A study on the returns to the introduction of new dual purpose (forage and grain) sorghum cultivars into the El Salvadoran dairy industry indicated that the cultivars were widely adopted by both large scale and small scale dairy farmers and the return to research investment in developing the cultivars was 37% with increased returns to both the producers and the consumers.**
- **Through the *bmr* associate award "Identification and Release of Brown Midrib (*bmr*) Sorghum Varieties to Producers in Central America (CA) and Haiti" 140 new technologies or management practices (*bmr* varieties and agronomic practices) were field tested in 2011. FY 2013 target is for 36,000 additional hectares under these technologies in CA and Haiti with a total of 7,500 rural households benefiting from these interventions.**
- **Through the Mali USAID Mission associate award in 2011: (1) 4,100 farmers applied new technologies on 3,700 ha, (2) 4,100 farmers received short term agricultural sector productivity training, (3) 3,900 rural households and 19 women's food processing organizations benefited.**
- **Through INTSORMIL core funding globally in 2011 (1) 10,000 ha under improved technologies, (2) 3,500 rural households, 400 agricultural related firms and 465 women's organizations benefited and (3) 65 public-private partnerships formed.**

8. How has the ME built on earlier investments?

Three examples:

(1) John Sanders work in Mali on the core project led to the receipt of the $5.25M Associate Award from the Mali Mission. This award provided the opportunity to move new technologies into the field over thousands of hectares in Mali. Farmers participating in this project more than double their yields and significantly increase their income.dd

(2) The cored supported breeding program at CENTA in El Salvador produced a large number of bmr forage cultivars that have high levels of digestibility in dairy cows and produce about 20% more milk than non bmr cultivars. The availability of these cultivars for dissemination to dairy farmers led to an Associate Award from USAID/W for rapid dissemination of these cultivars to six countries in Central America and Haiti. In less than 2 years the first bmr variety in CA was released in El Salvador in 2011, and two bmr varieties released in Nicaragua in May 2012. All CA countries and possibly Haiti will release at least one bmr variety in 2012-2013.

(3) The training program has provided human capacity and the capacity building program has provided research facilities to carry out host country research in collaboration with the US PIs. The continuing collaboration with a US mentor has provided guidance and research supplies needed by the host country to develop technology.

9. How does the ME continue to be forward thinking about research ideas and plans associated with the CRSP?

- **Attendance at USAID FtF meetings etc. to keep abreast of USAID objectives, goals and targets.**
- **Conducting regional workshops involving all stakeholders.**
- **Annual planning meetings with INSTSORMIL PIs**

- **Participation of PIs in national, regional and international meetings and congresses**
- **Access to Google Alerts and other website bulletins such SciDev.Net, BCPC News, USAID Reports etc.**
- **Reading international age development reports**
- **Discussions with NARS, NGOs, and other stakeholders while traveling internationally**
- **Attendance at seminars on campus**

B. Research Activities

1. Please describe whether the depth, breadth, and rigor of the research and development activities have been sufficient to allow the CRSP to achieve its stated goals and objectives. In general, comment on the depth versus breadth of the program.

   At the funding level for this cooperative agreement, INTSORMIL has developed a research portfolio that attempts to cover many aspects of technology development and transfer. The program has no duplication in activities either domestically or internationally. Basically, there is only one project that conducts research within a given research area. For the research projects only breeding is close to covering an area with sufficient depth and breadth. Additional resources would allow for additional expertise to be brought into the program to increase the scope of activity within a discipline.

2. In what ways are the research activities strategically sequenced to ensure targeted development outcomes within a known period?

   Working with host-country collaborators, each project appears to have the capability of achieving targeted development outcomes. Progress in breeding is more easily measured – varieties, number of hectares, number of farmers, etc. Progress in other disciplines is more difficult to measure. Logical performance indicators should be developed in consultation with the scientists that will enable the measurement of targeted development outcomes.

3. How and with what results has gender been taken into consideration in research design, training and outreach strategies at the research activity level?

   All programs are available to all farmers regardless of gender. Since the majority of small-holder farmers are usually female, females frequently have better access to new technology. Females participate in farmer field days, demonstrations, and workshops. Frequently females are the entrepreneurs attempting to develop small scale food processing business. INTSORMIL works with the entrepreneurs in developing their food processing businesses.

4. Are the Missions or other operating units (i.e., other Washington-based offices) aware of and have they sought to access the CRSP's technical, training and outreach expertise? Give examples.

No. It is the role of the US PI to empower host country collaborators with the capability and technology to reach out to other organizations within the individual country to assist in technology development and dissemination. The role of INTSORMIL is not only to develop human capacity and technology but to build the capability within the collaborators to reach out in behalf of the CRSP to other organizations within the country.

5. What can be done to capitalize on investments made from 2006-2011 - to broaden or accelerate progress? Which projects are likely to make the most progress towards fruition if another four years is granted? Are they scalable for greater impact? Should there be a focus on fewer high performing activities? Should there be a different mix of activities along the research continuum? Which ones need to be refocused or discontinued?

a. To investigate incorporating a Technology Transfer Project in the core program to facilitate technology coordination from all US PI projects and national program collaborative research into continued support of Technology Transfer Projects in all regions.

b. Projects likely to make the most progress towards fruition in a potential additional four years are:

- **Technology Transfer Projects**
- **Breeding Projects: Opportunities for working with NGOs and other donor organizations exist for multiplying and moving improved breeding lines and hybrids from the research area to the small farmer. These opportunities do exist.**
- **Plant Protection Projects**
- **Marketing, Processing and Poultry feed support projects**
- **Agronomic and Production projects**

All of these projects are scalable for greater impact. There is no single silver bullet for achieving maximum output. Greatest benefit will come from addressing the broad dimensions of production, utilization and marketing and incorporating those outputs into technology transfer to small farmers, entrepreneurs, local seed production businesses, NGOs and into cross collaboration between countries. Currently the research mix has been developed to meet the needs and goals of the FtF focus of USAID. Continued assessment of the array of projects will be evaluated and considered for refocusing or discontinuation.

C. Program Focus

1. How well has the ME balanced the research and implementation activities given the amount of funding provided? Please provide some reflection on how much emphasis should occur within the SMOG CRSP portfolio on basic research, applied research, and implementation.

Basic research or fundamental research is research carried out to increase understanding of fundamental principles. It is not intended to yield immediate commercial benefits.

Applied research is a form of systematic inquiry involving the practical application of science.

Implementation or technology transfer is the process of skill transferring, knowledge and technologies from research organizations to sorghum and millet farmers or food processing entrepreneurs.

Based on the above definitions the workplans developed involve no basic research. This is done by the PIs thorough other grant funding. Applied research such as breeding varieties are about 70% of the budget and implementation 30%. This ratio depends on the project and the current availability of applied research available to transfer. With the increased funding provided by USAID specifically for technology transfer this activity has increased in recent years. Much of the transfer of INTSORMIL developed technology is through partnering with NGOs, other USAID supported agencies, international organizations etc.

How does the SMOG CRSP respond to Title XII's objectives?

The Title XII goal is to improve the participation of U.S. agricultural universities in the Agency's efforts to increase world food production, and to encourage the provision of increased and longer-term support to the application of science to solving food and nutrition problems of the developing countries.
The primary objective is the development of the LDC capacity for research, education, and/or extension, the training of participants, the conduct of research, the building or strengthening of related institutional infrastructure, and/or the provision of university advisors to development projects, all in agriculture, agriculture, nutrition, agroforestry or closely related fields.

The INTSORMIL Program via the ME sub contracts with agricultural universities to conduct research and technology transfer activities that increase the production of sorghum and pearl millet as nutritious foods in some of the most hunger prone nations in the world. The program has been very successful ion the strengthening of human and institutional capacity in developing country programs responsible for sorghum and pear; millet research and technology transfer activities. A key characteristic of the CRFSP trained individuals in that it is a long term, and sometime a lifetime of mentoring and collaborating activity. Most students return home to continued employment with their national program and become d host country PIs of the INTSORMIL program which provides them with continued collaboration and funding and allows them to be a part of an international program. This allows them to keep current regarding the latest research procedures. INTSORMIL has many former students who are currently host country PIs and significantly contributing to food security in their country.

D. Collaboration, capacity building and outreach

a. What are some examples of partnerships and collaboration between host country and the U.S. PIs? How have they been effective at building the capacity of local researchers, policy makers and practitioners?

As an example the CA Regional project involves partnerships between the ME, Texas A&M University, Kansas State university, Purdue University, CENTA in El Salvador, INTA in Nicaragua, DICTA in Honduras, IDIAP in Panama, ICTA in Guatemala and INTA in Costa Rica plus the dairy industry in El Salvador (Proleche) and NGOs in these countries, FAO and Conmpatible Technololgy International, SICTA, IICA and the PCCMCA . A similar situation exists in all regional projects. This networking has been effective in building capacity of local researchers and practitioners but has had only a moderate influence on policy makers.

b. Compared to the research activities of the CRSP, what has been the level of effort and investment in training and institutional capacity building? **About 30%.** Has it been effective?

c. **Highly effective. From 1979-2011 INTSORMIL has provided training support for 1,191 students with 948 of them degree and 243 non-degree trainees. This is more than any of the other CRSPs. Of this total 28% were women. However, during the period from 2006-2011 about 50% of the trainees were women. Many of these returned to their national programs. Based on an impact assessment study of 766 INTSORMIL trainees scientific productivity has been high as indicated by 8,288 scientific or development documents produced and the fact that by these documents have been cited 68,8015 times. Former INTSORMIL trainees have contributed significantly to the >40 sorghum and pearl millet varieties released in 11 countries in Africa and Central America from 2006-2012. Recent (2006-2012) training activity gender ratio is about 50:50.**

d. How can impact of capacity building be captured (and measured) more effectively?
This has been done via Tim Dalton's impact assessment studies on long term training. We annually update the training database.

e. If the SMOG CRSP is extended for four years, what effect will this have on capacity building, particularly long-term training prospects for the program?

Students who have not yet completed their training program will be able to complete their degree.

We in some cases lack host country scientists to collaborate with. Thus we will target the training of individuals as per country and discipline based on training needs assessment conducted for training in the period 2012 to 2016.

f. How has the program cultivated a pipeline of students for long-term training opportunities?

Based on the regional coordinators and PIs' interactions with collaborating NARS they are able to know what disciplines the NARS need to carry out their research program.

However it has been difficult to find suitable candidates in some disciplines and with the lack of budget for training suitable candidates often seek funding from agencies other than INTSORMIL and often are successful.

g. Have PIs or the ME been successful in cultivating the right students for training?

Only moderately successful. We select students who are currently employees in a NARS program dealing sorghum and millet. Often there are no suitable candidates, another problem exists when there is only person in a NARS program in a specific discipline and if they come to the US or regional university for four years the US PI has lost a collaborator and is not able to conduct any in country research for the entire period of the INTSORMIL grant. Thus, the US PI is not able to even partially achieve any of the milestones listed in the contract with USAID. Another problem is the selection process. Sometimes the host country NARS dictate as to who they want to send for training. When scientists with poor English skills are selected they may waste a year or two taking English classes in the US at the rate of $40,000 per year (Most PIs' projects are only $80,000 per year prior to the removal of IDC by the PIs' university). Two years may be wasted as to the production of research results and taking course work and thus the graduation date is delayed requiring a request for an extension of the training period. A way to avoid this is to require the candidate to complete the English training in their home country and only be allowed to come to the US after successful completion of their English course.

h. What else, if anything, could be accomplished to ensure that the long-term training is targeting the right individuals/institutions?

First, if a new contract is awarded to the University of Nebraska as the ME 2012-2016 (or 2017?) a training needs assessment should be conducted in 2012. Based on the results of the assessment a 10 year plan should be developed for each region as to the disciplines that are required for a holistic national program based on the abiotic and biotic constraints and economic/policy needs. Based on the plan priorities need to be developed and training programmed as per the priorities. However, unless significant increases in funding are provided it will be impossible to fulfill the training needs in any of the countries. Right now, most PIs can only partially fund one student on INTSORMIL funding and even then a significant portion of the training budget is leveraged from grants other than INTSORMIL. Thus a training needs assessment and increased funding for training in the US or in the host country region could allow us to target the right individuals and provide the training required to develop national programs that can fulfill their mandate in sorghum and pearl millet research.

i. What outreach strategies have been integrated into project design to increase likelihood of uptake and utilization of research results?

With a moderate level of additional funding provided by UASID to the core project we have been able to implement technology transfer activities in each of the four regions. This has helped move some of the technologies to the farmers' fields. The biggest boost has been the receipt of the Mali USAID Mission award ($5.25M) and the USAID/W award

($1.1M) for disseminating bmr sorghum taechnolgy throughout CA and Haiti. We have recently begun to assess the potential for lCT as a means to transfer technology for the station to the extension staff and from there to the farmers' or possibly direct from the research station to the farmers. The assessment in Mali recommended a four phase project with phase 1 being radio communication and EReaders and later phases using mobile phone technology.

j. What have been the most effective strategies for outreach at the country level?

Working with partners such as NGOs in conducting demonstrations on farmers' fields with them taking part in carrying out the demonstration. These demonstrations convince the farmer and also by word of mouth the neighboring farmers are convinced.

k. What have been the outreach efforts at the regional or "global" level?

The regional (East, West and Southern Africa and Central America) technology transfer projects begun in 2010.

l. How has the ME communicated its activities to the global community through:

a. Hosted events, peer-reviewed journals and published work?

- **A list of peer reviewed publications 20016-2011 of INTSORMIL PIs has been provided to the EET. The citation factor of former INTSORMIL students and current PIs is impressive.**
- **A host of publicity materials and scientific documents is presented on the INTSORMIL website <intsormil.org>. Regional workshops involving all of the regional stakeholders have been conducted. The next one is in Ethiopia in September 2012.**
- **Participation of INTSORMIL scientists in national and regional meetings and international congresses. All of our CA bmr project collaborators presented papers in the recent PCCMCA meeting in Panama City and won awards for their presentations.**

b. USAID Missions and other operating units?

We provide quarterly reports to the USAID/Mali Mission. USAID Mali staff are included in our email address list which we use to inform all partners when new posts are downloaded on the website or new INTSORMIL-produced movies are added to the INTSORMIL YouTube channel.

c. Other donors and partners (other bilateral development agencies, etc.)

The ME publishes a Newsletter, reports and Impact articles which are posted on the website. We have an INTSORMIL YouTube Channel http://www.youtube.com/user/INTSORMIL where INTSORMIL produced movies are located. About 200 donors and partners in the USA and host

countries are informed of website downloads and other news via email messages.

d. How might the management entity better capture "impact" of their efforts at this level?

- **Increased movie production which is presently occurring.**
- **Funds to hire a full time editor for preparation of reports, newspaper articles and other publicity information.**
- **We now support a CRSP public relations agency along with other CRSPs that takes information we supply and produces a Newsletter and other documents especially for USAID, Congress etc. A full time editor would be able to more effectively feed the agency with INTSORMIL news and impact information.**

II. Administrative Review

A. What have been the roles/functions of the Board and technical advisory committee?

The Board of Directors Advises, sets policy and procedures, reviews progress and sets annual budgets.

The Technical Advisory Committee provides input on program planning and program review to the Program Director.

How cost effective has each been? **Highly cost effective having only one meeting per year**. Could they be more efficient? How? **Only by eliminating the annual meeting and changing to a conference call format.**

B. What has been the substantial involvement and contribution of the USAID AOTR?

- **Serves as a technical liaison between the ME and USAID**
- **Assists in obtaining Associate Awards form USAID Missions**
- **Assist in the review process. A link between reviewers and the ME.**
- **Provides input into the program planning and review by visiting host country project sites.**
- **Represents USAID in varietal release field days in host countries.**
- **Assists in obtaining USAID funding.**
- **Provides technical guidance by reviewing project proposals, workplans and annual reports.**
- **Serves as AOTR on the *bmr* Associate Award.**
- **A catalyst in promoting collaboration between the ME and CG Centers.**
- **Provides introductions when we request to visit USAID Missions in host countries so as to make them aware of our in country activities.**

C. What was the process for sub-award selection?

- **RFPs were developed by the ME for each project as based on the contract received from USAID.**
- **The RFPs were widely advertised via announcements to Deans of all Land Grant Universities and other relevant universities in the US and over the INTSORMIL website.**
- **The applicants submitted proposals to the ME in concordance with the RFP language and criteria.**
- **The ME submitted all proposals to and independent, external evaluation committee.**
- **The evaluation committee submitted their recommendations to the ME. In one case two proposals were rated equally and the ME requested the applicants to rewrite their proposals and the proposals were again sent to the evaluation committee for review and selection of the winner.**
- **The ME informed the winners and they were requested to develop a one year work plan and then a contract was developed.**

How effectively did the process yield a high quality, relevant portfolio of activities?

The process was effective in yielding a high quality, relevant portfolio of activities.

How consistent was it with the requirements of the cooperative agreement?

In complete agreement with the cooperative agreement.

D. Program Management:

1. What have been the challenges for the ME and how have they responded?

Challenge 1. Dealing with every day changes in USAID requirements. For example, aligning with FtF objectives midway in our contract period. Response: Requested PIs to follow the FtF Guide for INTSORMIL PIs in developing their workplans. Where there was a conflict with the FtF guideline as to countries we requested special permission through our AOTR.
Challenge 2. Budget cut in Yr 2006. A 35% reduction from the previous year. Response: Reduced budgets of projects and delayed selected activities such as training, research and technology dissemination.
Challenge 3. Having to rebid the program at 10 year intervals caused a 1-2 year loss of research and training activity. Response: No way for the ME to respond except to inform USAID of the results of their actions.

How has the ME promoted and maximized values such as collaboration, capacity building, and outreach among sub-awardees?

<u>Collaboration</u>: Being a Collaborative Research Support Program we collaborate at all levels. We collaborate with US universities in developing and conducting projects. Our PIs collaborate with other US scientists, NARS, NGOs, private industry, international agencies, CG centers and others in regional projects.

<u>Capacity building</u>: A major activity via our training programs and collaboration with host country institutes involves human capacity building and institutional strengthening. This is evident by the fact that the strong national sorghum programs are made up of former INTSORMIL trainees.
<u>Outreach among sub-awardees</u>: Sub-awardees collaborate with each other and with all relevant stakeholders. Networking is a major activity of our sub-awardees. This is a way to leverage funds and move technology form the research statin to the farmer level as many of our collaborators are technology transfer specialists.

2. How has the ME reviewed activities?

   The technical advisory committee in a meeting with the ME annually reviews the activities and the workplans and submits their recommendations to the ME.

3. What systems are in place to keep research activity on track according to the CRSP's goals?

   Development of RFAs and selection of proposals submitted.
   Development of annual workplans by PIs and their review by the ME before approval for funding.

4. In general, what has been the management style of the ME regarding PIs and sub-awardees?

   It is a bottom up approach and all PIs feel welcome to call the Director or Associate Director or office staff with any suggestions, requests, needs etc. Scientists also welcome direct communication with the ME. The ME bends over backwards to please the PIs when it contributes to the success of meeting INTSORMIL goals and objectives.

   How could it be improved?

   There is no need for improvement.

5. How have management problems been addressed?

   Through a dialog between the Program Director and the individual with the problem.

E. Financial Management:
   1. Have there been any problems regarding financial issues as perceived by CRSP participants at various levels (ME, Principle Investigator, Researchers, & in-country Collaborators)? How have problems been resolved?

      Timely processing of funds from USAID/W has been a constraint and has severely hampered our in country activities in Africa and Central America. Our subcontractors were not funded from October 1, 2011 to May 10, 2012. Funds for the Oct. 1, 2011 to September 30, 2012 period were received May 10, 2012. Result of this delay was a loss of one cropping season of research.

2. Have vouchers been processed in a timely way so as to minimize pipeline issues or payment lags?

Yes. This has not been a problem.

F. Monitoring and Evaluation (M&E):

1. What types of M&E have been undertaken by the ME?

I. Monitoring and Evaluation Plan Based on FtF Requirements from USAID

PIs will be responsible for monitoring their projects and will report the indicators to the Management Entity (ME), who will aggregate data and report it to USAID. We use the following relevant indicators as listed in the Feed the Future guidance on performance monitoring (http://www.feedthefuture.gov/monitoringevaluation.html):

Enhanced human and institutional capacity for development for increased sustainable agricultural sector productivity:

- **Number of farmers and others who have applied new technologies or management practices as a result of USG assistance**
- **Number of individuals who have received USG supported long-term agricultural sector productivity or food security training**
- **Number of individuals who have received USG supported short-term agricultural sector productivity or food security training**
- **Number of private enterprises, producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations (CBOs) receiving USG assistance**
- **Number of members of producer organizations and community based organizations receiving USG assistance**
- **Number of private enterprises, producers organizations, water users associations, women's groups, trade and business associations, and community-based organizations (CBOs) that applied new technologies or management practices as a result of USG assistance**
- **Number of stakeholders implementing risk-reducing practices/actions to improve resilience to climate change as a result of USG assistance**

Enhanced technology development, dissemination, management and innovation:

- **Number of hectares under improved technologies or management practices as a result of USG assistance**
- **Number of new technologies or management practices under research as a result of USG assistance**
- **Number of new technologies or management practices under field testing as a result of USG assistance**
- **Number of new technologies or management practices made available for transfer as a result of USG assistance**
- **Number of rural households benefiting directly from USG interventions**

II. Monitoring and Evaluation Plan Based on INTSORMIL Objectives as Recommended by USAID

Step 1. We developed the below table via discussions with the INTSORMIL CTO.

Step 2. The ME suggested throughputs and milestones in the table.
Step 3. The table was sent to all PIs with the ff questions for each Program objective:

- **Do these criteria apply to your project?**
- **Can you realistically meet these criteria in the time frame given?**
- **List any other criteria that you are measuring to meet this objective**

Step 4. The responses of the PIs were summarized and based on the summary we established the Yr3 and Yr5 Milestones

Objectives, targets, benchmarks and indicators, throughputs and milestones at SMOG CRSP Project Sites 2006-2011.

Objectives	Targets	Benchmarks and indicators	Throughputs	Milestones
1. Supply chain/markets	Increased yields and incomes	Increased farmer incomes	Farmer incomes	% increase Yr 3 and Yr 5
	Increased pearl millet quality	Increase in production area	Farmer incomes	% increase Yr 3 and Yr 5
	Increased use of sorghum as a feed source	Elimination of tannin in feed-type cultivars	% increase in markets for sorghum as a feed source	% increase Yr 3 and Yr 5
2. Nutrition, health and grain quality	Higher grain quality cultivars	High digestibility cultivars selected	X high grain quality varieties developed	x varieties released by Yr 3 and x by Yr 5
	New cultivar acceptance	Widespread adoption of cultivar	X % farmers accept new cultivars	x% farmers accept new cultivars by Yr3 and Yr5
	Increased nutrition of food and feed products	High starch digestibility cultivars developed	Nutritional deficiencies in diets decreased by x%	X% decrease by Yr3 and x% by Yr 5
3. ICSM	Increasd and stable grain yields	ICSM components identified	X% yield increase due to ICSM adoption	X% increase by Yr3 and x% by Yr 5
	Improved crop, soil and water management	Integration of ICSM components into packages	X% of farmers using ICSM packages	X% using ICSM practices by Yr3 and x% by Yr5
4. IPM	Increased grain quality	Tolerance to grain insects/pathogens	X% decrease in insect-damaged grain	X% decrease by Yr3 and x% by Yr5

		Efficient pest management tactics	**IPM packages developed**	**X varieties with insect resistance released**	**X variety released by Yr3 and x by Yr5**
		Reduced pesticide use	**Non-pesticidal strategies developed**	**X% decrease in pesticide used**	**X% decrease by Yr3 and x% by Yr5**
5.	**Genetic enhancement**	**Stable yielding genotypes**	**Genotypes with less variation in yields**	**X stable yielding genotypes released**	**X genotypes released by Yr3 and x by Yr5**
		More efficient water use by genotypes	**Decrease in damage due to drought**	**X drought tolerant genotypes released**	**X gentoypes released by Yr3 and x by Yr5**
		More efficient nutrient use by genotypes	**Savings in fertilizer costs**	**X N efficient genotypes released**	**X genotypes released by Yr3 and x by Yr5**
6.	**Genetic resources**	**Higher yielding genotypes**	**Selection of high yielding genotypes**	**X% increae in yield of new genotypes**	**X% increase in yield by Yr3 and x% by Yr5**
		Conservation of genetic biodiversity	**Decrease in rate of loss in biodiversity sensitive areas**	**X% decrease in use of biodiversity sensitive areas due to increased yields**	**X% decrease in use of biodiversity sensitive areas by Yr3 and x% by Yr5**
7.	**Partnerships and networking**	**Increased collaboration with partners**	**Networks established involving all stakeholders (private industry, NARS,NGOs, farmers, international agencies, CG centers, research and technology transfer agencies)**	**High research throughputs and high level of technology transfer activity**	**X% increase in grain production and x% of farmers using best management practices by Yr5%**

III. IMPACT Assessment Studies

Study 1: Global Impact of Sorghum and Millet Improvement Strategies
Study 2: Scientific Productivity of Long-term INTSORMIL Trainees

Study 3: Estimating the Returns to Research and Development from new uses (value added) of Sorghum

Study 4: Returns to the Introduction of New Sorghum Cultivars into the Dairy Industry of El Salvador

Study 5: Impact of the INTSORMIL Project in Mali and Niger

Study 6. The Economic Impact of New Sorghum and Millet Technology Adoption in Niger: Performance and Challenges

2. Are the indicators used effective at capturing and communicating the outcomes and impacts of research activities?

Yes. However, it is extremely difficult to obtain data input for many of the FtF indicators required by USAID. We estimate that to properly monitor and evaluate all of our projects it would cost about $300,000 per year. In that case there would be nothing to monitor as the funding of this exercise would come from research and technology transfer. One difficulty with the indicators required by USAID is that many of them require strong national research programs and most of the indicators refer to technology transfer actgivities. Thus, if the host country research program is weak it is difficult to develop the technology required to meet the indicators. Second, INTSORMIL is a research program and except for John Sanders who virtually lives in Mali we have to rely on the national extension program for technology transfer. Everyone knows that the extension programs are extremely weak to nonexistent so how can INTSORMIL meet indicators such as:

- **Number of hectares under improved technologies or management practices as a result of USG assistance**
- **Number of farmers and others who have applied new technologies or management practices as a result of USG assistance**

3. Are there appropriate indicators for the types of research undertaken in the program and the stages in the "research continuum"?

Most of the indicators are not appropriate to measure the impact of the INTSORMIL Program for reasons for reasons mentioned above.

4. Have baselines, if necessary, been established? **Yes**. When? **Baselines are established when the new technology is evaluated at the beginning of the activity at that site. The baseline is not a "before and after" approach but a "with and without" approach. For example, we compare the yield of a new variety with the locally grown variety under the same or similar conditions (yield influencing factors such as soil type being as equal as possible) on the same farm or on adjacent farms. Thus the yield baseline is the yield of the local check variety and the yield increase is the difference between new variety and the local check variety.**

5. Are data collected valid and of proper quality for reporting?

Some yes, some, maybe not. For example, number of varieties released is accurate information and worthy of reporting. The increase in farmer income due to the introduction of the variety is more difficult as many factors other than the new variety which is beyond our control contribute to the overall farmer income.

6. Have indicators capturing impacts and outcomes on higher levels been developed?

I am not sure as to what "higher levels" refers to.

Submitted by:
E.A. "Short" Heinrichs and John Yohe by email May 18, 2012

Annex D. Report on SMOG/INTSORMIL CRSP Site Visit and Discussion in Ethiopia and Zambia

I. Ethiopia Visit

Itinerary

- Travel from Washington was started on April 3, 2012 at 5:10 pm using United Airlines to Frankfurt, Germany and arrived around 7:15 am on April 4th.
- Travel from Frankfurt to Addis Ababa was started at 11:40 am on 4th of April using Lufthansa via Khartoum and arrived in Addis Ababa, Ethiopia at 9:15 pm on April 4, 2012.
- Travel to Melkassa Agricultural Research Center (MARC), near Nazreth started at 7 am on 5th of April using the INTSORMIL bought 4WD Toyota vehicle and arrived at 9:30 am. MARC is the base of INTSORMIL/SMOG main project Center for a long time and it is 117 km east of Addis Ababa.
- Meeting with SMOG CRSP local staff started at 10 am and continued up until 5 pm in the afternoon.

SMOG Crops: The main crop on which research has been carried out is sorghum and to a lesser extent on finger millet and pearl millet.

Institutions participating in SMOG CRSP: Among the national agricultural research systems, the Ethiopian Institute of Agricultural Research (EIAR) is the main one and SMOG is based in this institution. Other NARS institutions where collaborative work in research for development activities are Regional Agricultural Research Institutes such as Oromia Agricultural Research Institute (OARI), Amhara Agricultural Research Institute (AARI), Tigray Agricultural Research Institute (TRARI), Southern Agricultural Research Institute (SARI), Federal Ministry of Agriculture and Regional Bureaus of Agriculture, Ethiopian Seed Enterprise (ESE) and regional seed enterprises. Other private and non-governmental partners include Care Ethiopia (training farmers), World Vision, SG200, FAO, and ICRISAT (provide germplasm).

Areas of Research and Development: Improved variety development (Breeding), Soil and Water Mangement, Crop Protection, Food Science and Technology Transfer.

Researchers involved in SMOG CRSP: Almost all the senior and experienced researchers with PhD have left the program for other employment and for postgraduate studies. The current researchers are young recruits some of them with M.Sc. degrees. The names, qualifications and the addresses of these researchers with whom I had a meeting are presented in Table 1. The two Directors (Drs. Adefris Chere and Tolossa Debele) of EIAR whom I meet the next day are also listed in Table 9. The person who is acting like the local PI of SMOG CRSP is Mr. Alemu Tirfessa (M.Sc. and Sorghum Breeder). Alemu facilitated my visit and discussion with the other researchers.

Advanced Research Institutions (ARI) Partners: The researchers recognize the following ARIs as partners in the SMOG CRSP: a) Purdue University (Dr. Gebisa Ejeta, Sorghum Breeder); b) University of Nebraska- Lincoln (Dr. Charles Wortmann, Soil and Water); c) Kansas State University (Dr. Tesfaye Tesso, Sorghum Breeder, previously staff of EIAR and leader of INTSORMIL in Ethiopia, now provides sorghum germplasm to MARC); and d) University of Pretoria, South Africa (Dr. J.R.N. Taylor, Food Science). Dr. Taylor used to backstop the work of Dr. Seniat Yetneberk's food science activities at MARC and at the moment it is discontinued because Dr. Yetneberk left MARC. A new staff (Mr. Welday Hailu), who

completed his M.Sc. study at the University of Pretoria, is employed to resume the food science work at MARC and implement the activities planned during Dr. Senait Yetneberk's time.

Table 1. List of SMOG CRSP meeting participants at Melkassa Agricultural Research Center (MARC), Ethiopian Institute of Agricultural Research (EIAR) and Directors at EIAR in Ethiopia on April 5-7, 2012.

No	Name	Qualification/ Discipline	SMOG Component	E-mail	Telephone
1	Alemu Tirfessa	M.Sc., Breeding	Variety Development	tirfessa@hotmail.com	+251911887517
2	Adane Gebreyohannes	M.Sc., Breeding	Variety Development	Adanegy10@gmail.com	+251911926274
3	Amare Nega	M.Sc., Breeding	Variety Development	Amarenega83@gmail.com	+251918006854
4	Feyera Merga	B.Sc., Agronomy	Farming Practices/ Soil and Water management	feyeraliben@yahoo.com	+251912225311
5	Dejene Abera	M.Sc., Soil and Water	Farming Practices/ Soil and Water management	dejeneab@gmail.com	+251911861658
6	Jibril Mohammed	B.Sc., Soil and Water	Farming Practices/ Soil and Water management	jibrilmohm@yahoo.com	+251911719231
7	Welday Hailu	M.Sc., Food Science	Food Science	Welday_hailu@yahoo.com	+251912727943
8	Mekonnen Seme	M.Sc., Technology Transfer	Extension		
8	Getachew Ayana	PhD, Crop Protection	Center Director, MARC		
9	Adefris Chere	PhD, Plant Breeding	Director, Crops Research in EIAR	adechere@yahoo.co.uk	+251116462633
10	Tolossa Debele	PhD, Agronomy	Director, Soil and Water Research in EIAR	tolessadebele@yahoo.com	+251116460134

Soil and Water Research Activities:
According to the recent reorganization of research in EIAR, soil and water and agronomy are working together. The person who was handling the agronomy work in 2006 and 2007 was Mr. Tewodros, but he left for his PhD study in Australia. This person has also received short-term training at the University of Nebraska. Because the agronomy and soil and water units at MARC were merged, it was possible to continue the planned activities of SMOG CRSP in the absence of Mr. Tewodros. In addition, Mr. Feyera Merga is doing his M.Sc. on agronomy at Haramaya University, Ethiopia. Other staff who are handling agronomy, soil and water activities are Mr. Dejene Abera and Mr. Jibril Mohammed (Table 1).

The staff who are working on farming practices have developed technologies that help to conserve moisture for better crop growth in the moisture stressed Central Rift Valley and other areas of Ethiopia.

Some of the technologies include tied ride and skip rows. Tied ridge can be made by a tied ridger implement and helps to make moisture available for the growth of crops particularly in the drier areas. Skip rows could be 1:1 (one row sorghum and one row free) or 2:1 (two rows sorghum and one row free). The combined use of tied ridge, skip rows and fertilizer has helped to increase grain yields of sorghum. It has resulted in 50% yield advantage in some areas with critical moisture stress. However, these technologies are not disseminated to small scale farmers to bring impact owing to insufficient funding, which in turn had limited producing the tied ridger in adequate quantities for farmers. According to the researchers, farmers are aware of the technologies and are interested in using it, but there is no sustainable effort to scale up the technologies as a result of resource limitation.

The researchers acknowledge that the work they are doing is jointly developed with the US partner (Dr. Wortmann) and their partnership is also effective. Their work is monitored by the US PI every year and through regular contact with e-mail. Their work is also reviewed every year through the national system. Their main concern is that there is an overall funding limitation from SMOG CRSP.

Future needs of the researchers:

a) They fully support the continuation of the SMOG CRSP and would like to continue their work in the areas of moisture and nutrient management to generate additional technologies. Crop management is very critical in the low rainfall dry areas where sorghum is growing. New varieties will be productive through moisture conservation and nutrient management.
b) More funding desired to disseminate already available technologies for wide scale impact.
c) Continue capacity building to upgrade the knowledge and skills of the current young researchers and strengthen institution research facility in terms of soil lab.
d) Work on crop management practices of tef (*Eragrostis tef*). Tef is one of the crops mentioned in the SMOG CRSP, but no resource has been allocated to it. It is the staple cereal crop of Ethiopia that is grown on more than 2.7 million hectares every year. Because it is occupying a large agricultural land in Ethiopia, the government wants serious work to be done to enhance its productivity per unit area in its agricultural transformation plan.
e) The researchers suggested that the SMOG CRSP funds should be sent to the EIAR in a consolidated manner considering all SMOG activities in the country. These days, EIAR is getting reluctant to accept and manage small funds as the time and resource required in handling such funds in different accounts is high. The Institute accepts grant funds that include capacity building. When the fund for all activities of SMOG is integrated, the overall amount will be higher and EIAR will have one account to manage it. I feel that this will require having one local PI at the country level to follow up the different components of SMOG and the ME also need to work how to pull the resources from different US PIs to send them together to the local institution. Since all funds are attached to a work plan and activity, the PI in the host country will be able to manage it easily. It will also facilitate a consolidated reporting as the different components are addressing different issues along the value chain of the same commodity. I was able to note that the different researchers are reporting and interacting with the US PI directly, but horizontal interaction and cooperation among the SMOG team members at the host country level is weak. The team-work at the host country level will also help to reduce expenses, say for example, having one workshop instead of workshops by different units working on SMOG.

Food Science and Value Addition

Work on malt sorghum was initiated for brewery industries, but discontinued owing to the departure of Dr. Senait Yetneberk. The Food Science Unit has not so far developed products with long shelf life for the food market. Its work mainly focused on improvement at household consumption. It has trained

households on the preparation of weaning food for children around Gelemso, Western Hararghe Zone, Eastern Ethiopia by adjusting the energy contribution from sorghum as the local food was less in energy for children. Around 200 farmers were trained on how to maintain seed quality of sorghum for better income from the sale of grain. Sorghum grain quality going to the Ethiopian Commodity Exchange (ECX) is poor as a result of mixed varieties with different seed color and inert matter. The mixture contains both non-tannin and tannin sorghum grains. When farmers take non-mixed and pure grain sorghum to the market, price increases by 25-35%. Seeds of different varieties are mixed during planting and harvesting. Sometimes, farmers mix tannin sorghum varieties with newly released varieties at planting to control birds and avoid any possible risk of failure from the new varieties.

Future needs of the researcher:
As mentioned above, there is one M.Sc. holder working in food science and value addition of SMOG crops at the lab in MARC. The future work sought is in the area of developing long shelf life food products for the market. Of particular interest is to introduce, test, adopt and utilize SMOG value addition experiences from other regions and countries of the program. The beer industry in Ethiopia is flourishing and the researcher sees the paramount role and opportunity for sorghum to be utilized as a raw material for these breweries. At present, the Food Science Lab is constrained with facilities and funding that requires strengthening to contribute to value addition of SMOG crops.

Variety Development and Crop Protection
The National Sorghum Improvement Program in the country is coordinated from MARC and as a result materials from SMOG are tested throughout the country. The program works on open pollinated sorghum, hybrid sorghum, drought tolerance (mainly through earliness) and introgression of striga resistance gene into local varieties. For hybrid sorghum development lines come from Purdue and ICRISAT and the first hybrid variety was released in 2008. Currently, two hybrid varieties that give 27-30% grain yield advantage are available in the country. Breeding for the control of striga has resulted in the development and release of three varieties (*Abshir*, *Gobiye* and *Birhan*). The breeding program has striga sick plots at 'Pawe', 'Kobo', 'Humera' and 'Fedis' locations in different parts of the country. At the moment the breeding effort is continuing to combine hybrid vigor and striga resistance. Work on drought tolerance has also resulted in the development of two early maturing varieties.

The partnership with the US PI is strong and excellent. The breeding activities emanate from national need and strategy. There is frequent visit by the US PI to monitor activities in Ethiopia and interact with local partners. The researchers proudly appreciate the contribution of Purdue University in strengthening sorghum breeding in Ethiopia in capacity building and material supplies. They indicated that breeding supplies that are not available in the country are coming from Purdue. Since 2006, one PhD and one MSc training opportunities have been given. They also value greatly the Toyota Land Cruiser vehicle provided by the US PI towards the end of 2005, which is still functional despite accumulating more than 300,000 km mileage. They also have cold rooms availed by the SMOG CRSP.

Future need of the researchers:

a) Lab based screening for striga and contained facility: Sick plots alone are not enough for screening striga. Genotypes planted for screening completely fails at times due to drought and in such cases time is lost in the breeding effort.
b) The current young staff need skill and knowledge upgrading in controlled screening for striga in a contained facility. At present Mr. Asfaw Adugna is being trained at PhD level through USAID/Africa gene flow in sorghum. In addition, Mr. Taye Tadesse is also studying for PhD at Queensland University in Australia through SIMLESA Project.

c) There is need to train the new research technicians who handle the bulk of the work. The old and retiring ones have been trained by ICRISAT in the past.
d) The researchers would like to see enhanced breeding effort for hybrid sorghum, striga resistance and drought tolerance in the future.
e) Strengthening collaboration at host country level among sorghum value chain researchers in different institutions and agro-ecologies.
f) Research support and focus to intermediate and highland sorghum improvement.
g) Because production of sorghum seed is not well addressed by private as well as government parastatal seed companies, the researchers would like to strengthen community based seed production by using small seed pack system to satisfy needs of small scale farmers and bring more impact.

Technology Transfer

Mr. Mekonnen Seme, extension staff of MARC, is aware of INSORMIL since 2003. He indicated that in the past it had a strong technology transfer work on integrated striga management, varieties and fertilizer. According to him, since 2006 it has focused on breeding and agronomy only. He, however, acknowledged his technology transfer work on sorghum though it is not necessarily for SMOG CRSP by being attached to the breeding program. He thinks that technology transfer is not as visible as in the past. His technology transfer effort under MARC is limited in scope in that it considers five districts by taking five farmers per district. Technologies demonstrated and to a certain degree disseminated include hybrid varieties of sorghum, early and drought tolerant sorghum varieties, highland and mid altitude sorghum varieties, finger millet variety and he has also plan to work on one released pearl millet variety. He suggested that future SMOG CRSP should be on team approach in a research and development continuum. All the actors in the value chain of the crop commodity need to work together in a more cohesive manner. He emphasized that farmer preferred technologies be developed and for that researchers need to consider participatory variety evaluation with farmers. Overall, he believes that technology transfer in sorghum is weak and the approach needs to be revisited. More actors need to be part of the process for greater impact.

Discussion with Research Managers:

a) Dr. Getachew Ayana, Center Director of Melkassa Agricultural Research Center (MARC)

The Center Director appreciated the SMOG CRSP and look forward to its continuation for better impact. The young researchers are motivated to work because of their continuous link and support from ARIs in the USA. He also highlighted that striga resistant varieties are disseminated, but because of the vast agro-ecologies of sorghum in the country, it has not been possible to cover by research institutions alone and other actors need to be involved. He pointed out that individual to individual connection (referring to the host country researcher and the US PI) has both advantages and disadvantages. One weakness he noted is that when a staff from the host institution leaves for some reason (staff turnover is high in Ethiopia), gap is created and continuity of research work is affected and in most cases data are also not available. He suggested that system approach is better rather than depending on individual alone. In a system approach, research offices will make sure that the work is continuing and data transferred to newly assigned research personnel. He suggested funding a team of researchers through the system (EIAR) instead of individual researchers. This will help EIAR to monitor the program and ensure continuity of activities.

b) Dr. Adefris Chere, Crops Research Director, EIAR

All crop based research projects pass through Dr. Chere's Office. He has been heading this office since 2008, but his knowledge about SMOG CRSP is very minimal as it has been individual to individual partnership. As a whole the SMOG CRSP is not visible to him. Because of the rapid turnover of researchers, work plans and reports are not reaching him. What he showed me was the consolidated INTSORMIL activities report of the past by ME. He does not have any ongoing activities of SMOG in his directory. Similar to the MARC Center Director, he alluded to the point that projects be institutionalized instead of individual approach. The Ethiopian research system is highly institutionalized both at federal and regional levels where all activities are followed up and reviewed every year. However, when it is linked to individuals then the system will not be able to follow it up. This is what the Crop Research Director highlighted.

c) Dr. Tolossa Debele, Soil and Water Research Director, EIAR

The Director informed me that he is aware of SMOG CRSP for the past three years and he appreciated the partnership with the US PI (Dr. Wortmann). He also indicated that the problems being tackled by the project are pertinent to the Ethiopian condition and he would like to continue the collaborative work in a strong manner. He appreciated the training provided to his staff in the USA. He pointed out future collaborative research to focus on soil moisture conservation (drier areas are increasingly affected by climate change), conservation agriculture, small scale irrigation and soil fertility management. The current SMOG CRSP activities are fragmented as they are coming from different US PI to different individuals in the same institution. This made the funding per US PI small, but greater paper work to EIAR research managers. He emphasized that signing MOU for funds $5-15K is not attractive to EIAR as they require the same level of Institution resources to manage to that of big funding. Hence, it is better to consolidate activities and funds that go to EIAR/Ethiopia together and handle them in one account and local PI to follow up.

II. Zambia Visit

Itinerary

- Travel from Lilongwe, Malawi to Lusaka, Zambia was made using rented car from IITA-Malawi on April 15, 2012.
- Travel to Golden Valley Agricultural Research Trust, ZARI, Fringilla, Zambia, was made in the morning of April 16, 2012 (this site is 65 km to the north of Lusaka) for discussion and visit of sorghum and millet trial plots.
- Travel to University of Zambia was carried out on April 17, 2012.
- Return travel to Lilongwe was on April 18, 2012.
- Arrived in the USA on April 23, 2012.

SMOG Crops: The main crop on which research has been carried out is sorghum and pearl millet is another crop considered.

Institutions participating in SMOG CRSP: Among the national agricultural research systems, the Zambia Agricultural Research Institute (ZARI), Golden Valley Agricultural Research Trust (GART) and University of Zambia (UNZA).

Areas of Research and Development: Improved variety development (breeding), value addition and market development.

Researchers involved in SMOG CRSP: The researchers involved in SMOG CRSP are shown in Table 2. The sorghum breeding work is led by a senior scientist Dr. Medson Chisi, who is also Deputy Director of Research Services (all research stations) in ZARI. Dr. Chisi has been involved in INTSORMIL for a long time and also assists sorghum breeding in Southern Africa countries. Other researchers who work on sorghum in different disciplines are:

- Lloyd Mbulwe-Assistant Sorghum Breeder, ZARI, Golden Valley Agricultural Research Trust, Box 54, Fringilla, Zambia.
- Joseph Mwanamwenge – Agronomist, ZARI, Golden Valley Agricultural Research Trust, Box 54, Fringilla, Zambia.
- Godwin Kaula – Pathologist - ZARI, Mt. Makulu Research Station, P/B 7, Chilanga, Zambia.
- Petan Hamazakaza – Economist, ZARI, Golden Valley Agricultural Research Trust, Box 54, Fringilla, Zambia.
- Donald Mwandila – TRA , ZARI, Mt. Makulu Research Station, P/B 7, Chilanga, Zambia.
- Moses Ngwele – TRA, ZARI, Mt. Makulu Research Station, P/B 7, Chilanga, Zambia.
- Cecelia Mbilishi – TRA, ZARI, Mt. Makulu Research Station, P/B 7, Chilanga, Zambia.

Mr. Muuka handles pearl millet breeding at Mongu Station, western Zambia. He is also registered as a PhD student in the University of Zambia. The socioeconomics work on SMOG is led by Dr. Gelson Tembo and Mr. Moonga leads the food science work.

Advanced Research Institutions (ARIs) Partners: The researchers recognize the following ARIs as partners in the SMOG CRSP: a) Texas A&M University (Dr. Gary Peterson, Sorghum Breeder); b) University of Nebraska- Lincoln (Dr. David Jackson, Food Science and Technology); c) Ohio State University (Drs. Mark Erbaugh and Donald Larson); and d) University of Georgia (Dr. Jeffrey Wilson, pearl millet breeding).

Table 2. List of SMOG CRSP meeting participants at GART, Zambia Agricultural Research Institute (ZARI) and University of Zambia on April 16-17, 2012.

No	Name	Qualification/ Discipline	SMOG Component	E-mail	Telephone
1	Medson Chisi	PhD, Plant Breeder	Sorghum Breeding , GART, ZARI	medsonchisi@hotmail.com	+260966748094
2	Ferdinand Muuka	M.Sc., Plant Breeder	Pear millet breeding, ZARI	muukafp@yahoo.com	+260977427740
3	Gelson Tembo	PhD, Agric. Economist, UNZA	Value chain	tembogel@gmail.com	+260974779572
4	Bernadette Chimai	M.Sc. Agric. Economics, UNZA	Value chain	bchimai@unza.zm	+260977488477
5	John Shindano	PhD, Food Science, UNZA	Food science	jshindano@unza.zm	+260955753612
6	Himoonga Bernard Moonga	M.Sc., Food Science, UNZA	Food science	hmoonga@unza.zm	+260977690621

Sorghum Breeding

According to Dr. Chisi, the main focus of sorghum breeding is to shift sorghum from subsistence to commercial level and attain food security at the household level and develop hybrid varieties with quality traits. Sorghum is grown in marginal areas where maize does not do well. Specific areas addressed through breeding are a) enhancing genetic variability through germplasm collection and hybridization, b) work on stability of yield, c) development of open pollinated and hybrid varieties, d) address quality needs of end users, e) seed production of released varieties, and f) awareness creation on improved varieties via field days. Farmer participatory breeding is followed to develop farmer preferred varieties and other end users such as Zambia breweries. The breeding program has released a number of varieties that include hybrid varieties in Zambia to satisfy the needs of different end users. The promising breeding materials developed in Zambia have also been released in other southern Africa countries. For instance, seven lines have been released in Mozambique recently.

Seeds of improved varieties are produced in farmer's fields as government parastatals like ZAMSEED are not interested in producing sorghum seeds. NGOs working on crop diversification in the valleys and drier areas of Zambia contribute to training of farmers in seed production together with ZARI. Some of these NGOs are World Vision, FODIS (Food Crop Diversification Project), Harvest Help, Care International, OXFAM, WWF (World Wide Fund) and CRS. ZARI provides new batches of seeds every three years to minimize contamination of seeds in the hands of farmers. Extension officers from the Ministry of Agriculture also assist in educating farmers how to save produce as seed during harvest.

Dr. Chisi acknowledged that the sorghum breeding program wouldn't have been successful without INTSORMIL/SMOG support. Many research supplies like crossing bags are obtained from the US partner. SMOG also helped in covering operational expenses of trials, meetings with industries and other partners, in organizing field days, and acquiring research facilities. One interesting point Dr. Chisi mentioned is that in 2010 SMOG CRSP provided $130,000 grant for value chain work and the bank (Standard Chartered Bank) where the money was transferred in Zambia in turn donated ZARI a brand new Toyota 4WD Double cabin vehicle for field work that has been used since then.

Technology Transfer

Extension institutions are very slow in promoting sorghum and millets although the government has put crop diversification in its 5th and 6th national development plan. Lack of seeds of improved varieties and awareness were problems in technology transfer. Farmer's cooperatives are formed to contribute to technology transfer.

Issues to be addressed

- The senior sorghum breeder (Dr. Chisi) is closer to retirement and he has one assistant after a long period of time. However, if the assistant leaves for further study, there is no one to work in the program. The government is not recruiting new graduates to work in research. Research Technicians are also retiring and there is no replacement by the government.
- The relationship/partnership with the US PI (Dr. Gary Peterson) has been excellent. Communication with the US PI is regular and works well. E-mail has been the best way to communicate and the US PI visits the program one to two times per year. Dr. Chisi has free latitude in coordinating sorghum improvement in Zambia and the region. The SMOG vision is shared by the local industries and other stakeholders. Sorghum and millet breeding is strong in Zambia and that is the reason for Dr. Chisi to help other programs in the region.
- Getting training opportunities in the US is a long process that takes two to three months. Because of such long process Dr. Chisi has pulled out from such opportunities.

- The breeding program needs to upgrade the seed store as the cooling system is not functional at present.
- There is limited funding during the SMOG CRSP phase, but in the past there was more funding from INTSORMIL. For instance, there are no enough funds to train staff at PhD level in the USA.
- The current SMOG CRSP model is fragmented in to smaller grants and relationships are individual to individual and a local partnership at the host country level is weak.
- Technology transfer was funded once, but more work is needed to reach out more farmers and sorghum and millet growing areas. Vehicles are also required to do more dissemination work.

Recommendation

SMOG CRSP at the host country level should be multidisciplinary along the value chain of SMOG CRSP crops. Work in Zambia is carried out in more than one institution and information doesn't flow to the breeder and vice versa. More collaboration and interaction is necessary in Zambia as researchers from different institutions are addressing components of the same value chain of a crop.

Visit of Sorghum and Millet Trials at GART

I visited sorghum and millet trials that were towards maturity at GART field. The materials under development are intended for Regions I, II and III of Zambia. GART is a hot spot area for diseases and hence screening for diseases is possible through natural infection. Sorghum materials in the field were open pollinated, hybrids, crossing block, segregating genotypes, yield trials, close to 5,000 breeding materials. I noted the worry of Dr. Chisi on the fate of these materials upon his retirement. Pearl and finger millet materials are also being tested at GART. It was also possible to see the glabrous types of pearl millet (birds pick seeds easily) and the bristled types (where birds couldn't damage).

University of Zambia (UNZA)

Market studies, value addition and food science components of the value chain are being addressed at the University of Zambia. Dr. Tembo, who is leading the market study at UNZA expressed that the partnership with US PI's (Drs. Mark Erbaugh and Donald Larson) works well. He, however, mentioned that there was budget limitation for carrying out surveys by taking more samples and areas. He received a budget amount of $80,000 for the entire project period. Collaboration of UNZA researchers with the US PIs is strong, but there is no collaboration with the breeders at GART/ZARI within Zambia.

The food science component is led by Mr. Moonga. The work started by doing a survey to understand the problem. Quality of sorghum grain for market was poor due to mixed seeds and inert materials and hence getting good quality seed for processors has been a problem. Under SMOG CRSP, there is a PhD student at the University Nebraska (about to complete study) and another student is working in the University of Pretoria, South Africa.

Meeting with the Dean of School of Agricultural Sciences

I also had a chance to meet Dr. Mick Sikaenyi Mwala (Dean, School of Agricultural Sciences) about SMOG CRSP activities in UNZA. Dr. Mwala suggested the following:

- Synergies among UNZA, ZARI and other stakeholders need to be created at planning and activity levels.
- Budget should be attached to work plans and activities when transferred to UNZA. Auditors in UNZA have questioned budget sent in lump sum in the past although it was resolved eventually.

Recommendation

- Host country partnership among researchers from the same or different institutions should be strengthened to address the value chain issues of commodities efficiently.
- Training on entrepreneurship and product development is necessary
- The food science lab requires some equipment like de-huller and hammer mill.
- Host country platform is not there for SMOG CRSP stakeholders for awareness creation, visibility of the project and information exchange.
- It is necessary to strengthen research and extension linkage for technology dissemination
- More resource is required for technology dissemination.

AXIO SURVEY

SURVEY REPORT

Summary

Survey Name:
INTSORMIL CRSP Collaboration

Offering Name:
Melinda's survey

Offering Date:
4/22/12 to 5/13/12

Statistics
Started: **51** out of **85**
Opted out before starting: **0**
Completed: **49**
Drop outs after starting: **2**

Drop outs by page number:

- Page 1: **4**
- Page 2: **0**
- Page 3: **0**
- Page 4: **1**
- Page 5: **1**

Average completion times:

- Average Time To Complete Survey: **11 hours 22 minutes 6 seconds.**
- Average Time Spent Before Quitting: **14 minutes 36 seconds.**

Page 1

Question 1

Have you engaged in a collaborative research/development activity with a INTSORMIL CRSP collaborator during the current phase of the project (from 2007 to the present)? If no, you will directed to the closing page of the survey.

Yes		47 (92.16%)
No		4 (7.84%)
N/R		0 (0%)

Page 2

Question 2

In which geographical area of the world are you located?

Eastern & Southern Africa	21 (41.18%)
West Africa	11 (21.57%)
Central America & Caribbean	12 (23.53%)
South America	1 (1.96%)
Asia	0 (0%)
other	2 (3.92%)
N/R	4 (7.84%)

Question 3

Please tell us your scientific or development area of expertise.

Production science (including agronomy, weed science, soil science, pathology, breeding, etc)	28 (54.9%)
Social science (agricultural economics, sociology, gender etc)	6 (11.76%)
Post harvest (grain science, storage etc.)	3 (5.88%)
Food science (nutrition, product development)	8 (15.69%)
Human health	0 (0%)
Other:	2 (3.92%)
N/R	4 (7.84%)

Other Text:

- mycotoxins
- Celiac Disease Association

Question 4

Please tell us your crop focus in INTSORMIL.

Sorghum	43 (84.31%)
Millet	3 (5.88%)
Other	1 (1.96%)
N/R	4 (7.84%)

Page 3

Question 5

5.1 How important is sorghum production in your country?

Not very important relative to other crops	0 (0%)
Somewhat, but below average, relative to other crops	4 (7.84%)
Average relative to other crops	10 (19.61%)
Important relative to other crops	15 (29.41%)
Very important relative to other crops	18 (35.29%)
N/R	4 (7.84%)

5.2 How important is sorghum consumption in your country?

Not very important relative to other crops	0 (0%)
Somewhat, but below average, relative to other crops	6 (11.76%)
Average relative to other crops	15 (29.41%)
Important relative to other crops	10 (19.61%)
Very important relative to other crops	16 (31.37%)
N/R	4 (7.84%)

5.3 How important is sorghum trade (with other neighboring countries) to your country?

Not very important relative to other crops	4 (7.84%)
Somewhat, but below average, relative to other crops	14 (27.45%)
Average relative to other crops	14 (27.45%)
Important relative to other crops	9 (17.65%)
Very important relative to other crops	6 (11.76%)
N/R	4 (7.84%)

Question 6

6.1 How important is millet production in your country?

Not very important relative to other crops	13 (25.49%)
Somewhat, but below average, relative to other crops	9 (17.65%)
Average relative to other crops	5 (9.8%)
Important relative to other crops	8 (15.69%)

Very important relative to other crops	12 (23.53%)
N/R	4 (7.84%)

6.2 How important is millet consumption in your country?

Not very important relative to other crops	14 (27.45%)
Somewhat, but below average, relative to other crops	8 (15.69%)
Average relative to other crops	6 (11.76%)
Important relative to other crops	7 (13.73%)
Very important relative to other crops	12 (23.53%)
N/R	4 (7.84%)

6.3 How important is millet trade (with other neighboring countries) to your country?

Not very important relative to other crops	19 (37.25%)
Somewhat, but below average, relative to other crops	8 (15.69%)
Average relative to other crops	11 (21.57%)
Important relative to other crops	3 (5.88%)
Very important relative to other crops	6 (11.76%)
N/R	4 (7.84%)

Question 7

7.1 How much of your work/research time do you allocate to sorghum or millet research on an annual basis(including the time you allocate to INTSORMIL activities)?

Not important (<20%)	4 (7.84%)
Somewhat important (21-40%)	5 (9.8%)
Average (41-60%)	11 (21.57%)
Important (61-80%)	9 (17.65%)
Very important (81-100%)	18 (35.29%)
N/R	4 (7.84%)

7.2 About how much time do you allocate to INTSORMIL activities on an annual basis specifically?

Not important (<20%)	2 (3.92%)
Somewhat important (21-40%)	11 (21.57%)

Average (41-60%)	10 (19.61%)
Important (61-80%)	15 (29.41%)
Very important (81-100%)	8 (15.69%)
N/R	5 (9.8%)

7.3 How important is the financial contribution from INTSORMIL to your research activities? In other words, what percentage of your research budget is funded by INTSORMIL?

Not important (<20%)	6 (11.76%)
Somewhat important (21-40%)	7 (13.73%)
Average (41-60%)	9 (17.65%)
Important (61-80%)	11 (21.57%)
Very important (81-100%)	14 (27.45%)
N/R	4 (7.84%)

Page 4

Question 8

How would you describe your input into setting the research objectives and hypotheses of your project?

Poor, minimal input	1 (1.96%)
Weak, below average but positive	3 (5.88%)
Average, we shared equally setting the objectives	13 (25.49%)
Good, I provided more input into setting the objecitves	17 (33.33%)
Excellent, I led setting the objectives	12 (23.53%)
N/R	5 (9.8%)

Comments Text:

- None
- Developed the research agenda in line with the INTSORMIL research goal.
- In the first step our contribution was poor. But in the second step we actively contributed to the definition of the objectives workshopp, email exchange)
- INTSORMIL now encourages its co PIs in developing countries to set their research project. This is essential. My biggest disappointment is that we are not involved in INTSORMIL management and strategy meetings. I think this is very remiss and needs to be changed. It certainly is different in other CSRPs
- Sorghum pathologists are at a premium globally and I am probably one of very few who have the luxury of dedicating most of my time to this crop. It highlights the need for more training and research support in this field.

- We have promotted some of the sorghum materials we had imported evaluated and released in my country
- We (researchers and farmers) participatory identify and prioritize major constraints to sorghum and millet production in Uganda. Thereafter, we set the objectives of the research to address the constraints using both researcher managed and on-farm trials and demonstrations. Adaptive research is carried out to enable farmers fine-tune the proposed interventions to suit their environment.
- minimal input in setting the overall research objectives of the collaboration but excellent for setting objectives of specific research activities e.g thesis
- our proposals are reviewed and approved (or not) by the head of the research deptment.
- My activities guide farmers on the good storage technique to avoid or reduce pest damage in the storage facilities.
- Regards my research topic for my Masters degree in soil fertility, I set the objectives my self and the test crop is sorghum.
- I am happy to work with INTSORMIL
- INTSORMIL conçoit les technologies et je m'occupe du Transfert
- Participated in the planning meeting and later collected data; analysed results and prepared & submitted annual reports that were used to identify elite germplasm for use by collaborators in the USA in breeding programmes
- Involved in piloting specific-value chain interventions, which is the best option to address problems
- Initially the project objectives were set but we had back and forth exchange of ideas. Which resulted me making a in a larger input in subsequent years.

Question 9

How would you describe your input into setting the research methods used to reach your research objectives and /or test your hypotheses?

Poor, minimal input on methods	0 (0%)
Weak, below average but positive	1 (1.96%)
Average, we shared equally setting the methods	16 (31.37%)
Good, I provided more input into setting the methods	15 (29.41%)
Excellent, I led setting the methods	14 (27.45%)
N/R	5 (9.8%)

Comments Text:

- None
- I developed the objectives as well as the research methods as above
- In the first experiment, we contributed in throughtout the implementation of the proposal in other countries. In the second trial we defined the methology used
- Most studies are in my field of expertise ie epidemiology. I am dependent on molecular scientists iether within our institution or elsewhere due to my limitaqtions in this field.
- Tho possibilities are limited by financial restraints or the availability of equipment
- I have been treated as equal partner in developing methods of Striga control
- Being a researcher with over 22 years of experience, and knowledgeable with farmer

participatory research, we normally discuss with our collaborators at UNL, Purdue and OSU the methodologies to use to address the objectives.

- We start with survey on farmers knowledge that are then improved.
- Since am the one who designed my research topic the I had to come up with of the objectives suiting the topic.
- I need the support of international supporters
- Developed methods for screeningsorghum germplasm for resistance to sugarcane aphids and other major pests under Botswana conditions
- I involve other value chain actors in setting research priorities, implementation and evaluation

Question 10

Please describe your role in writing INTSORMIL research publications/reports. Reports include annual reports, research reports, working papers, conference papers, book chapters and manuscripts.

I initiate and lead writing research publications/ reports on INTSORMIL activities.	9 (17.65%)
I share writing research publications/reports equally with the PI and others on INTSORMIL activities.	12 (23.53%)
I contribute to writing research publications/reports on INTSORMIL activities.	20 (39.22%)
I do not contribute to writing research publications/reports on INTSORMIL activities.	5 (9.8%)
Other:	0 (0%)
N/R	5 (9.8%)

Other Text:

Question 11

If you have any ideas to share on how could your research collaboration could be improved, please describe in the space below. Please do not include financial or administrative issues as these will be discussed in the next section.

- None
- I am involved in setting the research agenda for the programme in this collaboration. Would like to have graduate students attached to the programme.
- Enhancing research on sorghum in sahelian countries is a very good idea. The collaboration however needs to be broader including not financing only but other aspects: capacities building,equipment...
- See my comments on question 8
- Greater pooling of resources and knowledge in the region, eg. my pathology inputs into regional trials, attendence of annual congresses within the region (mainly RSA, more training workshops locally.
- Maybe more interaction between the regional representatives and the collaborators in the setting and the comunication of overall objectives and specific proyect goals may improve

the coordination.

- The focus should include translating research reccomdendations to meaningful actions plans that can lead to policy change as most of our people do not read research publications.
- I agree with the colaboration form of INTSORMIL at this moment. We receive from INTSORMIL expert all the colaboration we need as neww germoplasm adapted for our areas, technical asistance and others.
- The funding levels have been very low, we have not reached a stage of linking farmers with sorghum market, which is readly available but need to demonstrate more, so that farmers can increase product.
- I believe promotion of improved sorghum varieties needs to be strengthened in the country. There were growing interest from smallholder farmers on improved varieties.
- The collaboration is quite o.k.
- Research collaboration could be improved if IP in West Africa get more funds.
- Including more training for collaborators and keader projects will improve the research methods and activities, also to be more in touch with principal investigators,
- As it is needed in research,it is always important to start the project together (From writing to implememntation)for all collaborators involved. It is was there with but need to be insisted
- By includingall disciplines by objective in one project(Breeding, Agronomy, Weed science, Socioeconomics,marketing,Technologytransfer)&capacity building(short and long term training &infrastructure).
- The research collaboration could be improved by scientist visit, sharing experience and more participary activities with farmers.
- LA INVESTIGACIÓN EN VARIEDADES DE SORGO bmr ES MUY IMPORTANTE PARA PANAMÁ, PORQUE CONSTITUYE UNA ALTERNATIVAMENTE PARA LA PRODUCCIÓN DE FORRAJE DE EXCELENTE CALIDAD
- So far our research collaboration is going on well.
- we have to make our collaboration strong for the future!!!
- De 2007 à 2012 notre collaboration a porté uniquement sur le millet, je souhaiterais qu'elle s'étende sur le sorgho.
- Have more training in breeding
- INTSORMIL could organise conference for collaborators to share their research findings with collaborators from the US and the regions involved in Africa
- INTSORMIL has been very supportive both in Food Science aspect and poultry feed production and many students and staff have benefited immensely at B.Sc, M.Sc and PhD levels.
- Alternate annual planning/review visits by respective PIs ie one in USA and two in Zambia. Most equipment should have been provided at the beginning of the project.
- Re-introduction of PI exchange field visits/tours/meetings and more germpasm exchange and joint evaluation as well as short-term trainings.
- concentrate on understandingthe low production and utilization of sorghum and millet despite their many attractive production attributes

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Question 12

Relative to the project objectives, is INTSORMIL financing sufficient to meet the project objectives?

Insufficient to meet objectives (<20%)	9 (17.65%)
It somewhat covers the cost (21-40%)	3 (5.88%)
It covers around half of research costs (41-60%)	16 (31.37%)
It nearly covers the research cost (61-80%)	14 (27.45%)
It fully covers research costs (81-100%)	3 (5.88%)
N/R	6 (11.76%)

Comments Text:

- The money received is at least sufficient to carry out a trial. Other aspects needs to be taken into account
- Funds not adequate to cover an adequate sample and various objectives
- The amount of money we have been receiving was very small compared to what to be achieved
- In our case Intsormil covers all costs except our salaries (covered by our government)
- Although most costs are covered for the immediate activities, the research needs are enormous and could be expanded but for the financial implications/limitations
- There are somo cost that asume the national institution as salary of the expert in charge of the projec here in Nicaragua and others.
- Is funding my PhD thesis work. It would be good if we could have additional financial support for continuing research on ISFM with sorghum as entry point.
- None
- Sometimes Research efficiency is hampered by delayed INTSORMIL funding.
- The joint funding with other partners allow to achieve the objectives
- The funds were insufficient as only about $5,000 on average was available each year. It would have been better to have bought the equipment first and then conduct the research than buy one or two items each year
- capacity building should be included like PhD training.
- Regards financial issues,it is sufficient to meet the objectives.
- Jusqu'ici, INTSORMIL n'intervient que dans trois(3) Cercles sur huit(8), dans douze(12) villages sur deux mille quarante(2040) de la Région de Mopti.
- It did not include support to graduate students who would have ensured greater impact. It also didnt include overheads.

Question 13

How important in INTSORMIL funding to conducting your research/development activities?

Essential, I could not conduct research on these topics without it.	12 (23.53%)
Very important, it funds 61-80% of my research costs.	11 (21.57%)
Important--it contibutes around 41-60% of my research budget	13 (25.49%)
Somewhat important--it contibutes around 21-40% of my research budget	5 (9.8%)

Not important, it funds less than 20% of my reseach activities	3 (5.88%)
Other:	1 (1.96%)
N/R	6 (11.76%)

Other Text:

- No Response

Question 14

How difficult is it to comply with financial reporting requirements implemented by the program to receive funds and/or reimbursements?

Very difficult	0 (0%)
Difficult	7 (13.73%)
Similar to other projects	15 (29.41%)
Easier than most projects	11 (21.57%)
Not a problem at all	12 (23.53%)
N/R	6 (11.76%)

Question 15

Overall, how would you rate the administrative requirements set up by the program to comply with USAID guidelines?

The most burdensome of all projects I am involved with	0 (0%)
Much more burdensome than other projects	2 (3.92%)
About average relative to other projects	32 (62.75%)
Easier than most projects	11 (21.57%)
N/R	6 (11.76%)

Question 16

Please add any additional comments that you would like to share regarding financial management of your project from the perspective of a host-country collaborator/investigator.

- There is a need to increase the level of funding to enable us reach more farmers and have impact over wide areas.
- My University needs to hold all the original invoices for auditing purposes. The INTSORMIL requirement to supply these cannot be complied with.
- The ME has always assisted with the management of funds and provided useful guidelines when needed.
- Adquate funds is requied to show an impact in research
- The financial management is done by my boss, Vilma Calderon. She interacts with the

regional coordinator. I have no experience with it.
- Allocatioins to be transferred sooner in order to be able to meet deadlines (both to have money available to do the research and to spend money before dealines)- percurement processes can take long.
- the institutional arrangements about financial managemest are very slowly, Materials are not on time for some of the projects.
- Receipts are deposited, administered and audited by Univ. and ext. accountants. Recovery of individual receipts is difficult - official statements of expenditure without these are not accepted by INTS
- INTSORMIL is a very good way for America to help Mali
- El financial management has to be conducted by NGO becuase the finacial managemnet by govermment is more complicated and later
- INTSORMIL is the only external project helping us with budget, germoplasm and technical assistance.
- National agricult research institute is poorly funded by the government, therefore funding on reimbursements bases sometime is difficult because no funds to begain with exist for later be reimbursed.
- None
- It would be good in the future to send funds on time
- Though the objectives of INTSORMIL on soil and water conservation are very important to Ethiopia,popularization of generated technology is not addressed.Thus, the impact is not yet seen.
- Host-country collaborator very supportive.
- It is satisfactory
- To get better outputs, out of the available funds at least 60% should have been available in the first year for the acquisition of equipment so that the research activities would have started non stop
- finance more to address more areas and more people!!!
- Financial management has no problems with it because am able to set up field trials on time and get data as required by the project.
- Search more agile handling and timely funds to carry out field work
- Pas de commentaires
- I have had no problems with financial management.
- Institutional management procedures have room for improvement especially in notification of PIs on expenditure to avoid overexpenditure

- End of Survey -

Annex F. Organization of INTSORMIL/SMOG CRSP (prepared by Joan Frederick, May 11, 2012)

Management Entity

Scientists:
John M. Yohe, Program Director
E.A. Heinrichs, Associate Director

INTSORMIL Program Staff
Joan Frederick, Financial Officer
Kimberly Christiansen, Program Assistant, Diane Sullivan, Accounting Specialist
Anthony Michaelsen, Media Communications Coordinator

U.S. Principal Investigators
Sustainable Plant Protection and Production Systems: KSU 101-Leslie, WTAM 101-Pendleton, KSU104-Prasad, UNL 101-Wortmann,
Germplasm Enhancement and Conservation: ARS-101 (Project ended), PRF 101 & PRF 105-Ejeta; KSU 104-Tuinstra; TAM 101-W. Rooney, TAM102-Peterson.
Crop Utilization and Marketing: KSU 102-Hancock, OSU 101 Erbaugh/Larson; PRF 102-Hamaker; PRF-103-Sanders, TAM 103-L. Rooney

Regional Programs:
West Africa Regional Program: Coordinators -B. Hamaker and B. Pendleton
Southern Africa Regional Program: Coordinator -G. Peterson
East Africa Regional Program: Coordinator - C. Wortmann
Central America Regional Program: Coordinator - W. Rooney

USAID/MALI Associate Award
E.A. Heinrichs: Technical Management
Diane Sullivan: Financial Management

BMR Central America Award
E.A. Heinrichs: Technical Management
Kimberly Christiansen: Financial Management

Annex G. Sorghum, Millet & Other Grains Collaborative Research Support Program (CRSP)

Award Number: EPP-A-00-06-00016-00

Technical and Administrative Performance Evaluation
SCOPE OF WORK

Purpose

The purpose of this evaluation of the Sorghum, Millet & Other Grains Collaborative Research Support Program (SMOG CRSP) is to assess program performance, to identify program successes and areas of concern, to help program implementers improve program effectiveness, to provide recommendations, and to inform the U.S. Agency for International Development (USAID) on future programming and support of the SMOG CRSP. As the program has now been ongoing for five years, this evaluation will serve to inform USAID on whether to extend the SMOG CRSP as it currently exists, to suggest significant modifications to the program, or to not continue funding.

Background of the Sorghum, Millet & Other Grains CRSP

USAID established an agreement with University of Nebraska - Lincoln in September 2006 to serve as the Management Entity for the Sorghum, Millet & Other Grains CRSP and to administer the program for the five-year period of October 1, 2006 through September 29, 2011. This Cooperative Agreement- Leader with Associate award (EPP-A-00-06-00016-00) was the result of an open and competitive process to identify a university with predominant technical capacity in sorghum and millet research.

The Program aims to improve food security and nutrition, enhance farm income and improve economic activity in the major sorghum and pearl millet producing countries in Africa and Central America. The program also supports education, training of foreign, and U.S. graduate students, and strengthens the technical capacity of developing countries' researchers and research managers through exchanges and visiting scientists programs.

The program brings together animal nutritionists, biotechnologists, breeders, cereal chemists, economists, entomologists, food scientists, plant pathologists and weed scientists from several US universities, ARS/USDA and national research programs in East Africa, West Africa, Southern Africa and Central America to collaboratively address critical constrains to subsector productivity in the following areas.

1. Genetic resource conservation/enhancement: Diverse ecological conditions in major growing areas of the target crops, coupled with diverse ethnic customs and preferences have resulted in the rich genetic diversity of the target crops - sorghum, millet, finger millet, fonio, and teff. This diversity has imparted great resilience and broad adaptation, making these crops of enormous

significance for genetic improvement interventions. Conservation and management of these genetic resources are, therefore, important considerations for further enhancement and exploitation of these crops. The SMOG scientists and their collaborators collect, preserve, screen for desirable traits and use these valuable resources in breeding and management research to support the productivity and profitability of both US and partner country agriculture.

2. Yield and stability: The target crops are commonly cultivated in a semi arid environment of the tropics characterized by erratic rainfall pattern, inadequate moisture, degraded soil resources, rampant pest and disease problems and noxious weeds. The resource poor farmers of the region lack the necessary capital to invest in inputs and modern farm implements. As a result, they continue to rely on rudimentary farming techniques and tools. The small producers in the region have little or no access to technologies and lack critical technical and business management knowledge to competitively participate in the market place. The combined effect of this lack of resource, technology and know how has been a continued decline in productivity per unit area, rampant poverty, hunger and chronic food insecurity for the producers and consumers of the region. The SMOG research in this area is aimed at developing improved soil and water management best practices (e.g. soil organic management, nutrient use efficiency), high yielding and stress resistant (e.g. drought tolerant, weed and insect pest resistant) crop varieties, innovative production/farm management best practices and integrated insect pest management (IPM) techniques to increase over all farm output and sub-sector profitability.

3. Market development: The target cereals are cultivated mainly for traditional home consumption. Often perceived as food for the less privileged, they rarely, if any, attract significant research investments. However, agribusinesses interest in transforming them to high value food, feed and industrial products is growing rapidly, thereby opening up new market and income opportunities for producers. Under this program area, the SMOG CRSP food technologists, nutritionists, and breeders are working closely with agribusiness in the US and developing countries to develop varieties that are cost efficient alternatives for use in animal feed and beverage industries and products that appeal to the urban middle class consumers. Similarly, the Program’s marketing experts and economists are empowering farmers to apply innovative marketing strategies and business management practices to competitively participate in the market place.

4. Institutional capacity: Over the years, USAID has supported the education of developing country scientists in sorghum and pearl millet research. Many of these scientists currently occupy non-research positions or they are nearing retirement. Therefore, there is a need for new generation of scientists who will provide the scientific basis for sustained generation and deployment of new technologies that produce sustainable income for farmers and satisfy consumers demand for food and fiber. Under the institutional capacity program area, the SMOG CRSP supports formal graduate level trainings; mentors young scientists through on the job training, and strengthens the capacity of senior researchers through collaborative research program planning and implementation, and visiting scientists and exchange programs.

The portfolio of the SMOG CRSP consists of complementary research and development interventions assembled based on the premise that a holistic and value chain approach is essential to meaningfully address the issue of hunger, poverty and food security in developing countries.

The research and development interventions aim to provide technological, human capital and policy solutions to critical challenges that collectivity constrain sector productivity.

Scope of Work

The Collaborative Research Support Programs (CRSPs) operate under a five-year time horizon, but there is "some assumption" that a five year extension will be provided based on a record of good performance during the first five year period and continued relevance of the CRSP to the overall Agency portfolio and development priorities and the availability of funds. In the present context, this means that the SMOG CRSP should fit well with USAID's Feed the Future (FTF) development goals and agriculture research agenda. As the timing of this evaluation process did not coincide with the end date of the initial five-year award period, the program was granted a one- year extension with the potential for an additional four-year extension contingent on the above factors and the outcome of a higher level evaluation of the CRSP model concurrently being undertaken by the Board for International Food and Agricultural Development.

An "External Evaluation" will provide USAID and the Management Entity (ME) with constructive feedback on the past performance and management of the SMOG CRSP, but equally important review the program's current "technical relevance" and make recommendations regarding a four-year extension of the CRSP, including the identification of research, extension and capacity building activities that should be considered when developing a Technical Application of the program for 2012 – 2016.

This External Evaluation will focus on progress the SMOG CRSP made towards achieving its Technical Vision as stated in the Technical Applications approved by USAID. The planned evaluation will assess the CRSP's performance through review of project documents, site visits, and correspondence with participants and stakeholders. The External Evaluation team (EET) will gather findings, produce conclusions and recommendations In addition, the program evaluation will also assess the administration and implementation of the SMOG CRSP by the University of Nebraska - Lincoln as a "partner" with the Office of Agriculture Research and Policy, Bureau of Food Security, USAID in terms of its technical leadership and management of the contractual and financial aspects of this complex multi-institutional global program.

Criteria for Assessment: The EET will evaluate the CRSP in the following areas by responding to the questions below.

I. Technical Review

A. Scientific/Technical Leadership

1. What are examples of scientific/technical leadership displayed by the ME?
2. What are examples of scientific technical leadership displayed by the individual project Principle Investigators (PIs)?
3. How are the separate research activities integrated into a broader strategy or thematic programming areas responsive to Feed the Future?
4. How does the ME facilitate engagement of the research activities or themes with other development programs in regions where the CRSP is active?

5. How well has the ME facilitated the participation of new partners? Give examples of how program RFA/RFPs are designed and how opportunities are advertised and made available for new PIs.
6. Are the levels of effort, award size and research project duration sufficiently balanced to allow the CRSP to achieve program goals and objectives?
7. What have been the significant accomplishments in terms of research, outreach, and dissemination?
8. How has the ME built on earlier investments?
9. How does the ME continue to be forward thinking about research ideas and plans associated with the CRSP?

B. Research Activities
   1. Please describe whether the depth, breadth, and rigor of the research and development activities have been sufficient to allow the CRSP to achieve its stated goals and objectives. In general, comment on the depth versus breadth of the program.
   2. In what ways are the research activities strategically sequenced to ensure targeted development outcomes within a known period?
   3. How and with what results has gender been taken into consideration in research design, training and outreach strategies at the research activity level?
   4. Are the Missions or other operating units (i.e., other Washington-based offices) aware of and have they sought to access the CRSP's technical, training and outreach expertise? Give examples.
   5. What can be done to capitalize on investments made from 2006-2011 - to broaden or accelerate progress? Which projects are likely to make the most progress towards fruition if another four years is granted? Are they scalable for greater impact? Should there be a focus on fewer high performing activities? Should there be a different mix of activities along the research continuum? Which ones need to be refocused or discontinued?

C. Program Focus
   1. How well has the ME balanced the research and implementation activities given the amount of funding provided? Please provide some reflection on how much emphasis should occur within the SMOG CRSP portfolio on basic research, applied research, and implementation.
   2. How does the SMOG CRSP respond to Title XII's objectives?

D. Collaboration, capacity building and outreach
   1. What are some examples of partnerships and collaboration between host country and the U.S. PIs? How have they been effective at building the capacity of local researchers, policy makers and practitioners?
   2. Compared to the research activities of the CRSP, what has been the level of effort and investment in training and institutional capacity building? Has it been effective? How can impact of capacity building be captured (and measured) more effectively?
   3. If the SMOG CRSP is extended for four years, what effect will this have on capacity building, particularly long-term training prospects for the program?

4. How has the program cultivated a pipeline of students for long-term training opportunities? Have PIs or the ME been successful in cultivating the right students for training? What else, if anything, could be accomplished to ensure that the long-term training is targeting the right individuals/institutions?
5. What outreach strategies have been integrated into project design to increase likelihood of uptake and utilization of research results? What have been the most effective strategies for outreach at the country level?
6. What have been the outreach efforts at the regional or "global" level?
7. How has the ME communicated its activities to the global community through:
    a. Hosted events, peer-reviewed journals and published work?
    b. USAID Missions and other operating units?
    c. Other donors and partners (other bilateral development agencies, etc.) How might the management entity better capture "impact" of their efforts at this level?

II. <u>Administrative Review</u>

A. What have been the roles/functions of the Board and technical advisory committee? How cost effective has each been? Could they be more efficient? How?

B. What has been the substantial involvement and contribution of the USAID AOTR?

C. What was the process for sub-award selection? How effectively did the process yield a high quality, relevant portfolio of activities? How consistent was it with the requirements of the cooperative agreement?

D. Program Management:
    1. What have been the challenges for the ME and how have they responded?
    2. How has the ME promoted and maximized values such as collaboration, capacity building, and outreach among sub-awardees?
    3. How has the ME reviewed activities?
    4. What systems are in place to keep research activity on track according to the CRSP's goals?
    5. In general, what has been the management style of the ME regarding PIs and sub-awardees? How could it be improved?
    6. How have management problems been addressed?

E. Financial Management:
    1. Have there been any problems regarding financial issues as perceived by CRSP participants at various levels (ME, Principle Investigator, Researchers, & in-country Collaborators)? How have problems been resolved?
    2. Have vouchers been processed in a timely way so as to minimize pipeline issues or payment lags?

F. Monitoring and Evaluation (M&E):
    1. What types of M&E have been undertaken by the ME?
    2. Are the indicators used effective at capturing and communicating the outcomes and impacts of research activities? Are there appropriate indicators

for the types of research undertaken in the program and the stages in the "research continuum"?
3. Have baselines, if necessary, been established? When?
4. Are data collected valid and of proper quality for reporting?
5. Have indicators capturing impacts and outcomes on higher levels been developed?

Evaluation Methodology: The evaluation will be based on a review of project documents, site visit with the Management Entity, and phone interviews. The EET members will communicate, as appropriate to the nature of the queries, with the ME, principle and co-principle investigators and host-country stakeholders, as well as other relevant members of the regional or global development and research communities. The evaluation will consist of the following steps:

A. The EET will schedule an internal team planning meeting via phone with the USAID Agreement Officer's Representative (AOR) and other USAID staff as needed. In this meeting and in a desk review the evaluators will ascertain the relevance of all the individual projects to the overall objectives of the CRSP. Evaluators will be familiar with a number of documents before the meeting, including the CRSP agreement, program operations and other documents, annual reports; original research activity proposals and work plans for Years 1-5. All of these, as well as other CRSP documents will be provided by the AOR and/or the CRSP ME, and will constitute materials necessary for the Desktop Review. During this phase, the EET will review documentation relevant to the Areas of Evaluation and may conduct phone interviews with the ME, Principle Investigators and other stakeholders The purpose of the Desktop Review is to provide background and determine the areas of additional attention to be addressed during a site visit with the ME to properly execute the evaluation.
B. The EET will then discuss with the AOR an Evaluation Work Plan outlining additional interviews or other types of information collection, e.g. conducting a brief survey of host-country researchers, to achieve the objectives of the evaluation. The EWP will also outline the time required to successfully complete the evaluation.
C. Conduct the evaluation.
D. Upon completion of the evaluation, the EET will submit a draft evaluation report to the AOR. The report should include recommendations for enhancing the performance and impact of the CRSP. It shall also make recommendation regarding a possible four-year extension of the CRSP as follows:
    a. Refinement of program themes or topics covered by the CRSP;
    b. Number and depth of activities in the CRSP's portfolio;
    c. Type of activities relative to the research and development continuum;
    d. Improving/expanding impact;
    e. Major organizational or procedural changes.

Evaluation Report: The EET will submit its draft report on or about April 20 after the field work is completed. This report will address the specific items mentioned in this SOW and any other relevant issues the EET feels should be addressed. The draft will be submitted electronically in MS Word format to the CRSP AOR. USAID will then return comments and

suggestions for consideration to the EET within 15 days. The final revised report should be submitted to USAID no more than 15 days after the return of the comments and suggestion from USAID. All comments should be sufficiently addressed in the text or an explanation provided. An oral presentation of the final report will also be made to USAID and the ME via an arranged phone call. The EET may choose any structural outline for submission of the report that includes the topic areas outlined above; however, the following is a suggested outline for the report:

I Title Page
II Table of contents
III List of Acronyms
IV List of Tables
V List of Figures
VI Executive Summary
VII Findings and conclusions
    A. Including responses to each item in the SOW
VIII Recommendations
IX Appendices
    A. Statement of work
    B. Itinerary
    C. List of Persons Contacted
    D. List of Materials reviewed

Level of Effort and Time Frame: The level of effort for the entirety of this scope of work will consist of no more than 20 person days for the Team Leader and up to 12 days for the other EET members over a period not to exceed 44 days. The USAID AOR will be available to the team as a resource person but will not contribute directly to preparation of the report.

Team Composition and Qualifications

The technical areas of focus of the CRSP require that expertise on the panel will be appropriate for the CRSP being evaluated. Team members must have the expertise necessary to evaluate the program and to address the evaluation questions. The team members must familiarize themselves with USAID's priorities and objectives in the economic growth sector, and particularly the USG Feed the Future research strategy. USAID will designate one team member as team leader.

Administrative/management review member (1): A senior administrator with a minimum of ten years experience managing multifaceted international development research and/or university-based programs. The preferred candidate will be familiar with both university-based programs and USAID (or other donor) funded programs. A background in agricultural or rural development is preferred. The candidate would also have (1) demonstrated capacity to conduct program evaluation; (2) an understanding of USAID's foreign assistance goals, and its particular objectives related to collaborative research, agricultural development and food security; and (3) the ability to analyze issues and formulate concrete recommendations orally and in writing.

Technical team members (2): Must be recognized experts on international development related to agriculture and/or rural development with expertise in the focus areas of the SMOG CRSP. Team members will be chosen from those who have experience in such areas as plant breeding, agricultural production/ agronomy, food/feed processing, animal nutrition and/or agricultural economics. Technical team member candidates will also have demonstrated (1) capacity to conduct program evaluation; (2) thorough understanding of research methodology; (3) experience in effectively conducting outreach and dissemination to policymakers, development practitioners and/or the private sector; (4) the ability to analyze issues and formulate concrete recommendations orally and in writing.

Annex Table 1. CROP MANAGEMENT TECHNOLOGIES APPROVED/RECOMMENDED TO FARMERS BY INTSORMIL SUPPORTED NARS PROGRAMS 2006-2012

Year	Crop (sorghum or pearl millet)	Country	Technology approved/ recommended for release to farmers (sowing rate, spacing, fertilizer, pesticide, herbicide, tied ridges etc.)	Comments
2006	Sorghum and Pearl millet	Mozambique	Planting dates	Early maturating varieties are damaged by bird; so, delaying planting can avoid bird damage because it will mature in same time with landraces
	Sorghum	Mozambique	Sowing rate	Farmers were using high planting rate about 20 kg/ha; so we recommend a rate of 10 kg/ha
	Sorgo	El Salvador	Uso de herbicida para el control de *Ciperus sp.*	Se utiliza en un 40% de la superficie sembrada (30,000 ha)
	Sorghum Híbrido INTA Forrajero	Nicaragua	- Densidad poblacional: depositar de 25 a 30 semillas por metro lineal y a 60 cm de distancia entre surco. - Fertilización: Utilizar 2 qq de la formula completa 12-30-10 o su equivalente al momento de la siembra. - Utilizar 3 qq/mz de sulfato de amonio a los 25-30 días después de la siembra. Utilizar esta misma cantidad a los 8 das después de cada corte. - Época de siembra: Mayo - Para control de Spodopetra frugyperda: 1 litro/mz de Diazinon	
	Sorghum/Millet	Niger	Microdosing	In Niger most of farmers are poor
	Sorghum	Niger	Tied ridge	With applying small amount of fertilizer or microdosing

				farmers can improve Sorghum and Millet production
	Sorghum/Millet	Niger	Thinning	
	Sorghum	Uganda	Fertilizer rates	
	Sorghum	Uganda	Fertilizer substitution value of manure and cover crop	
	Sorghum	Uganda	Reduced tillage	
	Pearl Millet	Zambia	Mid-Nov.-mid-Dec. planting; 4-6 kg/ha seed rate; 60x30 cm Inter- x Within row spacing; 2x50 kg/ha 'D' Compound 10:20:10:6 N:P:K:S basal and 1x50 kg/ha 46% N top-dressing fertilizers; weeding twice; Thinning leaving 1-2 seedling/hill 2-3 weeks after sowing.	Technologies applicable to all varieties. Sowing when soil moisture is sufficient. In Region I, planting can be delayed up to early January as per rainfall availability. Bird-scaring a must on non-Bristled varieties from grain formation till grain is hard.
2007	Millet	Burkina, Mali	Microdose application	Increased yield increase >50%
	SORGO	El Salvador	Dosis optima de fertilización para la producción de grano.	La utilizan los productores de semilla certificada.
	Sorghum/Millet	Niger	Microdosing	
	Sorghum	Niger	Tied ridges	Tied ridges technique had improved water holding capacity in heavy soil; and protected Sorghum plant against drought
	Sorghum	Ethiopia	Tie-ridging	Conditions where appropriate better defined
2008	Sorghum	Mozambique	Rate of fertilizer application	The recommendation is 100 kg/ha of NPK 12:24:12 and 100 kg/ha of Urea 46%
	Millet	Burkina	Mechanized zai + compost	Increased yields > 50%

	SORGO	El Salvador	Producción artisanal de semilla de variedades mejoradas de sorgo para pequeños agricultores.	200 tm de semilla cada año.
	Sorghum Variedad INTA –RCV y variedad INTA SR-16	Nicaragua	- Densidad poblacional: 18 a 20 semillas por metro lineal a 70 cm entre surco, para una población de 152,000 a 170,000 platas / mz. - Fertilización: Utilizar 2 qq de la formula completa 12-30-10 o su equivalente al momento de la siembra. - Utilizar 2 qq/mz de urea 46 % a los 25-30 días después de la siembra - Época de siembra: Postrera del 10 de agosto al 7 de septiembre. - Para control de Stenodiplosis sorguícola: aplicar 1 litro/mz de Cypermetrina. - Para control de Spodopetra frugyperda: 1 litro/mz de Diazinon, cypermetrina o lorsban. -	
	Millet	Niger	20 kg P and 30 kg N	Increased grain yields >100%
	Sorghum/Millet	Niger	Microdosing	
	Sorghum	Niger	Tied ridges	
	Sorghum/Millet	Niger	Thinning	
2009	Sorghum	Mozambique	Bio-charcoal application for water management and conservation	There was a need to improve water retention on sand soils
	SORGO	El Salvador	Producción artisanal de semilla de variedades mejoradas de sorgo para pequeños agricultores.	200 tm de semilla cada año.
	Sorghum	Ethiopia	Melkam/WSV-387	
	Sorghum	Ethiopia	ESH-1 (P-501AX ICSR14) /hybrid	35-45 Qt/ha
	Sorghum	Ethiopia	ESH-2 (ICSAXICSR50)/hybrid	35-43 Qt/ha
	Sorghum	Ghana	26 kg P	Increased grain yield >50%
	Sorghum	Ghana	90 kg N	Increased grain yield >100%
	Sorghum/Millet	Niger	Microdosing	
	Sorghum	Niger	Tied ridges	
	Sorghum/Millet	Niger	Thinning	

2010	SORGO	El Salvador	Producción artisanal de semilla de variedades mejoradas de sorgo para pequeños agricultores.	200 tm de semilla cada año.
	Sorghum	Ghana	Improved genotypes (Kapala / Dorodo)	Increased grain yield >100%
	Sorghum Variedad INTA –Sorgo Mejor	Nicaragua	- Densidad poblacional: 27 semillas por metro lineal a 70 cm entre surco, para una población de 170,000 platas / mz. Para ensilaje 30 semilla /ml para 250,000 plantas /mz. - Fertilización: Utilizar 2 qq de la formula completa 12-30-10 o su equivalente al momento de la siembra. - Utilizar 2 qq/mz de urea 46 % a los 25-30 días después de la siembra - Época de siembra: para grano en postrera del 20 de agosto al 5 de septiembre. Para forraje ensilaje en la segunda quincena de Mayo. - Para control de *Stenodiplosis sorguícola*: aplicar 1 litro/mz de Cypermetrina. - Para control de *Spodopetra frugyperda*: 1 litro/mz de Diazinon, cypermetrina o lorsban.	
	Sorghum	Niger	100 kg N	Increased grain yield >100%
	Sorghum/Millet	Niger	Microdosing	
	Sorghum	Niger	Tied ridges	
	Sorghum/Millet	Niger	Thinning	
	Sorghum	Ethiopia	Skip-row planting	Tigray only
2011		Mozambique	Organic fertilizer for soil fertility improvement using legumes	Most of the farmers can't afford to buy inorganic fertilizers; organic fertilizers can improve organic material and soil fertility
	Sorgo	El Salvador	Densidad optima de siembra de variedades de sorgo bmr para la producción de grano y forraje.	Nuevas variedades con menos lignina que requieren un manejo agronómico un poco diferente.
	Millet	Mali	Improved genotype (S0 x SAT)	Increased yield >60%

	Sorghum	Mali	CAN (contour ridges)	Increased yield >30%
	Sorghum	Mali	NuMass based fertilizer recommendation	Increased yield >30%
	Sorghum Variedad INTA ESHG-3	Nicaragua	- Densidad poblacional: 20 a 22 semillas por metro lineal a 70 cm entre surco, para una población de 170,000 platas / mz. - Fertilización: Utilizar 2 qq de la formula completa 12-30-10 o su equivalente al momento de la siembra. - Utilizar 2 qq/mz de urea 46 % a los 25-30 días después de la siembra - Época de siembra: Postrera del 10 al 28 de agosto. - Para control de Stenodiplosis sorguícola: aplicar 1 litro/mz de Cypermetrina. - Para control de Spodopetra frugyperda: 1 litro/mz de Diazinon, cypermetrina o lorsban.	
	Sorghum/Millet	Niger	Microdosing	
	Sorghum	Niger	Tied ridges	
	Sorghum/Millet	Niger	Thinning	
	Sorghum	Uganda	Fertilizer recommendation refined	
2012	Sorghum	Mozambique	Use of organic pesticide using chili, and leaves of forest trees to avoid maize weevil damage in the storage	Under study, results of three years are promising
	Décrue sorghum	Mali	Increased plant population and decreased spacing	Increased yield >50%
	Décrue sorghum	Mali	Traditional genotypes (Saba soto and Saba tienda) greater yield stability	
	Sorghum Variedades BMR: CI 0943 y CI 0947	Nicaragua	- Densidad poblacional: 18 a 20 semillas por metro lineal a 70 cm entre surco, para una población de 152,000 a 170,000 platas / mz y para ensilaje 30 semillas/metro lineal. - Fertilización: Utilizar 2 qq de la formula completa 12-30-10 o su equivalente al momento de la siembra. - Utilizar 2 qq/mz de urea 46 % a los 25-30 días después de la siembra - Época de siembra: Postrera del 10 de agosto al 7 de septiembre. Y para forraje ensilaje siembra de primera. - Para control de *Stenodiplosis sorguícola*: aplicar 1 litro/mz de Cypermetrina. Para control de *Spodopetra frugyperda*: 1 litro/mz de Diazinon,	

			cypermetrina o lorsban	
	Sorghum/Millet	Niger	Microdosing	
	Sorghum	Niger	Tied ridges	
	Sorghum/Millet	Niger	Thinning	
	Sorghum	Uganda	Fertilizer optimizer tool released	

Summary: 85 crop management practices released in 12 countries in Central America and Africa

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May 25, 2012

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Annex Table 2. VARIETAL RELEASE HISTORY (2006-2012) OF INTSORMIL SUPPORTED NARS BREEDING PROGRAMS

Year	Crop (Sorghum or Pearl Millet)	Country	Name of Variety Released	On-farm Yield of New Variety	Yield of Local Check Variety	Amt. of Seed Produced (Breeder, Basic/Foundation, Certified)	Qualities other than Yield (Drought Tol./Forage Quality/Food Type, etc.)	Comments
2000-2006	Pearl millet	Mozambique	Kuphanjala1	600-1200 kg/ha	200 kg/ha	50 kg breeder seed, 500 kg foundation seed	Drought tolerance good for forage quality, and Stay green	Bird attack when planted early November
	Pearl millet	Mozambique	Kuphanjala2	1000 kg/ha	400 kg/ha	50 kg breeder seed, 500 kg foundation seed	Drought tolerance good for forage quality, and Stay green	Bird attack when planted early November
	Pearl millet	Mozambique	Changara	1200 kg/ha	300 kg/ha	50 kg breeder seed, 500 kg foundation seed	Drought tolerance good for forage quality, and Stay green	Bird attack when planted early November
	Sorghum	Mozambique	Macia	3,0 – 5,0 ton/ha	400 kg/ha	1500 kg foundation seed	Drought tolerance good for forage quality, and Stay green	Bird attack when planted early November, suitable for low land and semi-arid areas of South and South of Tete Province
	Sorghum	Mozambique	Chokwe	2,0 – 4,0 ton/ha	400 kg/ha	1000 kg foundation seed	Drought tolerance good for forage quality, and Stay green, moderate susceptible to grain mold in areas with more than 4 months of rainfall season	Bird attack when planted early November, suitable for low land and semi-arid areas of South and South of Tete Province
2006	Sorgo	El Salvador	CENTA SS-44	Variedades 85 SCP 805 y ES-790 (fotosensitivas) identificadas como más				Estas variedades la utilizan los pequeños agricultores en una superficie de 35,000 ha en el sistema de

				eficientes en el uso del Nitrógeno en el sistema de asocio maíz-sorgo. Con fertilizante producen 3.5 tm/ha y sin fertilizante 2.5 tn/ha, un 18% más que las locales.				asocio maíz-sorgo.
	Sorgo	El Salvador	CENTA SS-44	12 tm/ha/corte	8 m/ha/corte	25 tm/año de semilla certificada	25 tm/año de semilla certificada	Incrementa en 21% la producción de leche.
	Sorghum	Mali	GRINKAN	3000	1500	Breeders seed Seed foundation is certified	Human food and Forage quality	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum/Millet	Niger	90-SN-7					
	Pearl Millet	Zambia	Mulatiwa	600	520	200	Medium-tall, early, disease-tolerant, grey grain	Adapted in all millet areas. 2.9 t/ha yield potential.
	Pearl Millet	Zambia	Liseli	750	520	250	Tall, medium-early, long panicles, disease-tolerant, grey grain	Adapted to Regions I & II. 2.7 t/ha yield potential.
2007	Sorghum	Mozambique	Adaptation and yield stability evaluation	3,0- 5,0 ton/ha On-station 1,5 2,0 ton/ha	1,0-1,5 ton/ha	Breeder seed maintenances		Under National Plant Trials with rain feed conditions
	Sorghum	Mali	NIATHITIAMA	2500	1000	Seed foundation is certified	poultry feed and human food	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum/Millet	Niger	SSSD-35			1200T		Early maturity type; high resistance to Sorghum midge very serious Sorghum pest in Niger; the damage

								of this pest can estimated up to 85% of yield lost .
	Pearl Millet	Zambia	Dola	1030	630	300	Medium-tall, Bristled-Bird and disease-tolerant, medium –early, grey – nutritious grain	Nationally and Regionally demanded, Adapted to all millet areas. 3.0 t/ha yield potential.
	Pearl Millet	Zambia	Mulatiwa			500		
	Pearl Millet	Zambia	Liseli			650		
2008	Sorghum	Mozambique	Adaptation and yield stability evaluation			Breeder seed maintenances		Under National Plant Trials with rain feed conditions
	Sorgo	El Salvador	ZAM 911	2.7 tm/ha grano	2.4 tm/ha	25tm cada año semilla artesanal	Buena adaptación para el asocio con maíz	Altura de planta mediana con buen rastrojo.
	Sorghum	Mali	SANGATIGUI	2000	1500	Seed foundation is certified	Human food	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum/Millet	Niger	L-861			2000T		
	Pearl Millet	Zambia	Dola			3,000		
	Pearl Millet	Zambia	Mulatiwa			500		
	Pearl Millet	Zambia	Liseli			550		
2009	Sorghum	Mozambique	Adaptation and yield stability evaluation			Breeder seed maintenances		Under National Plant Trials with rain feed conditions
	Sorgo	El Salvador	ZAM 912	3.9 tm/ha grano	2.6 tm/ha grano	15 tm cada año semilla artisanal.	Doble propósito grano y forraje	Buena calidad de grano.
	Sorghum Hybrid	Mali	SEWA,	3500	1000	Seed foundation is certified	Human food and Forage quality	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum	Niger	L861;L724C;Serie of lines derived from crossing MDK			1615T	Good food quality; Drought tolerance;	Most of those new lines had good Combiner with our 2 females: NE223 A and

			by Sureno; developed through Single Seed descent Method MDSU-55-2;MDKSU-29-1;MDK-SU-55-1;MDK-Su-53-2:MDKSU-49-1;MDKSU-30-1:MDKSU-2-2;MDKSU-10-1;MDKSU-79-1;MDKSU-47-1;MDKSU-47-1;MDKSU-29-2;MDKSU-66-1;MDKSU-53-1;MDKSU-60-1;MDKSU-55-2					ATX623;on our Hybrids development program. On farm tests will be carry out in the coming years
	Pearl Millet	Zambia	Dola			3,000		
	Pearl Millet	Zambia	Mulatiwa					
	Pearl Millet	Zambia	Liseli					
2010	Sorghum	Mozambique	8 varieties			400 kg breeder seed produced	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Submitted to committee of plant release
	Sorghum	Mali	TIANDOUGOU COURA	2500	1000	Seed foundation is certified	Human food and Forage quality	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum	Nicaragua	SR-16	13ton/ha		3500T	Grain Hybrid; Food Quality; Macio PS Sorghum for Subsistence Varieties in Dry Areas of Nicaragua; Red Grain Sorghum Cultivar	
	Sorghum/Millet	Niger	I-28			3500T		Good adaptation to sandy soil; good grain

								quality; having B reaction. Conversion into an adapted A line for our Hybrid program is in the Selection process.
	Sorghum	Zambia	[SDS5006xWSV –187)23-2-1	5 – 8 tons/ha	4-6 tons/ha	80 kgs	White tan plant, food quality bold grain, drought tolerant	Ideal for regions I and II
	Pearl Millet	Zambia	Dola			600		
2011	Sorghum	Mozambique	Matica 1	On-farm 1,400 kg/ha; On-station 2,500 – 3,000 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Material still in the field
	Sorghum	Mozambique	Matica 2	On-farm 1,250 kg/ha; On-station 2,500 – 3,000 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Material still in the field
	Sorghum	Mozambique	Tocole	On-farm 1,400 kg/ha; On-station 2,500 – 3,200 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Material still in the field
	Sorghum	Mozambique	Otela	On-farm 1,500 kg/ha; On-station 2,500 – 3,500 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Material still in the field
	Mozambique	Mussequesse	On-farm 1,200 kg/ha; On-station 1,300 – 3,000 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Mozambique	Mussequesse
	Mozambique	Sima	On-farm 1,250 kg/ha;	600-1,000 kg/ha	Breeder seed 200 mˆ2;	Good grain qualities, wide range of	Mozambique	Sima

			On-station 2,200 – 3,000 Kg/ha		6 ha Foundation seed Planted	adaptation over sorghum production areas, drought tolerance and stay green suitable for forage ; intermediate maturing		
	Mozambique	Mapupulo	On-farm 1,300 kg/ha; On-station 2,500 – 3,000 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Mozambique	Mapupulo
	Mozambique	Mucuvea	On-farm 1,800 kg/ha; On-station 3,000 – 4,000 Kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Good grain qualities, wide range of adaptation over sorghum production areas, drought tolerance and stay green suitable for forage	Mozambique	Mucuvea
	Sorgo	El Salvador	CENTA S-2 bmr para forraje.	2.5 tm/ha grano y 45 tm/ha de biomasa (MS)	2.0 tm/ha grano y 50 tm/ha biomasa (MS)	15 tm/año semilla certificada.	Forraje multicorte, 25% mas digestible que el sorgo normal.	Incrementa la producción de leche y carne en los bovinos.
	Sorghum Hybrid	Mali	NIELENI	3000	1000	Seed foundation is certified	Human food	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum Hybrid	Mali	GRINKAN YEREWOLO	3000	1000	Seed foundation is certified	Human food and Forage quality	Very white flour allows various industrial uses such as cakes, biscuit
	Sorghum	Nicaragua	ESHG-3				Grain Hybrid; Food Quality; Macio PS Sorghum for Subsistence Varieties in Dry Areas of Nicaragua; Red Grain Sorghum Cultivar	

	Sorghum	Nicaragua	INTA Segovia	4.9ton/ha			Grain Hybrid; Food Quality; Macio PS Sorghum for Subsistence Varieties in Dry Areas of Nicaragua; Red Grain Sorghum Cultivar	
	Sorghum;Millet	Niger	L-724-C;New Generation of Hybrids was released:NE223 AX90SN-1;NE223AX 90SN-2;NE223AX90S N-3;NE223A X 90SN-4;NE223A XL-724-C;NE223AX P9405;NE223AX P9402;NE223A X Macia;NE223AX L-861;NE223A X SERIE of MDK-SU (all give good Hybrid)			5000T		
	Sorghum	Uganda	SESO1	2205	1883	~3 t?	White grain, suitable for clear beer	
	Sorghum	Uganda	SESO2	2137	1883	~3 t?	--ditto--	
	Sorghum	Uganda	SESO3	2570	1883	~3 t?	Good storage	
	Sorghum	Zambia	ZSV – 36R	5 – 7 tons/ha	4-6 tons/ha	60 kgs	Red seeded OP variety, brewing	Ideal for bird prone areas in Regions I, II & III
	Pearl Millet	Zambia	Dola			2,500		
2012	Sorghum	Mozambique	03CS-GWT 115	2,300-3,500 kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Grain mold and drought resistant and stay green	Material still in the field and not yet submitted to committee of variety release; Suitable to semi-arid

								areas
	Sorghum	Mozambique	02CS-30932	2,300- 2,900 kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Grain mold and drought resistant and stay green	Material still in the field and not yet submitted to committee of variety release; Suitable to semi-arid areas
	Sorghum	Mozambique	04CS-523-2-1	2,500- 3,800 kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Grain mold and drought resistant and stay green	Material still in the field and not yet submitted to committee of variety release; Suitable to semi-arid areas
	Sorghum	Ethiopia	Melkam/WSV-387			20 basic and pre-basic seed	Drought tolerant and good for *injera* making	INTSORMIL Partially supported the national program
	Sorghum	Mozambique	S35	2,000- 4,060 kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Triple purpose, grain for food, steam for forage and juice for ethanol production	Material still in the field and not yet submitted to committee of variety release; Suitable for high rainfall areas
		Sorghum	Mozambique	KARI-MTAMA 1	2,200- 3,600 kg/ha	600-1,000 kg/ha	Breeder 200 mˆ2 Planted	Triple purpose, grain for food, steam for forage and juice for ethanol production

ADDITIONAL COMMENTS:

- In 2012, Guatemala is scheduled to release varieties: 85 SCP 805 and ES-790 for intercrop with maize system of small farmers. Also CI0929 and CI0947 varieties both with "bmr" genes for cattle fodder.
- In the same year in Honduras is planned to release the 85 SCP 805 and ES-790 for intercrop with maize system of small farmers. Also CI0929 and CI0910 both with "bmr" genes for cattle fodder.
- Nicaragua will release varieties "bmr": CI0943 and CI0947 on May 15 next.

- These releases will be made in October 2012. Costa Rica and Panamá will release two bmr varieties at 2013.

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Annex Table 3. List of persons contacted for the host-collaborator survey.

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