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**Transfer of Sorghum, Millet Production, Processing
and Marketing Technologies in Mali**

**Annual Report
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by

**Management Entity
Sorghum, Millet and Other Grains Collaborative Research Support Program
(INTSORMIL CRSP)**

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Production-Marketing



Décrue sorghum



Processing



Training

1. Acronyms and Abbreviations

ACRONYM	DESCRIPTION
AMEDD	Association Malienne d'Eveil au Developpement
BNDA	Banque Nationale de développement Agricole Mali
CONFIGES	NGO/ Gao
CRRA	Centre regional de Recherche Agronomique
DRA	Division de la Recherche Agronomique
FCFA	Franc CFA
Ha	Hectare
IER	Institut d'Economie Rurale
IICEM	Integrated Initiatives for Economic Growth In Mali
LTA	Laboratoire d'Technologie Alimentaire (IER)
MOU	Memorandum of Understanding
MT	Metric tonne
NGO	Non Governmental Organization
RCGOP	NGO/ Tomboctou
SAA	Sasakawa Foundation
WFP	World Food Program
WTAMU	West Texas A&M University

2. Introduction

The goal of this project is to raise farmers' incomes in a sustainable way. Experience indicates that increasing input use for sorghum and millet in West Africa depends upon the simultaneous adoption of the inputs for higher productivity (Improved cultivars, inorganic fertilizers, pest management tactics and credit), the introduction of improved agronomic practices ((Higher plant populations, increased use of organic fertilizers and the introduction of water conservation/harvesting techniques) and improved marketing to respond to the price collapse problems and to improve grain quality to increase demand from food processors (and for farmers to receive a premium price for quality). Improved product marketing insures that farmers will earn enough money to pay for the increased inputs, especially improved seeds and inorganic fertilizer. Without these higher input levels the soil fertility cycle of declining yields, low farm incomes and minimal input purchase will not be broken.

The principal constraint to the introduction of the new cultivars, inorganic fertilizer and associated technologies is the low profitability of the higher input use systems. Many national and international scientists have produced a backlog of good technologies. The missing components are the research and extension to increase the profitability of these intensive production systems by 1) moderating or eliminating price collapses with better marketing strategies and 2) improving farmer access to and increasing the efficiency of the principal input markets.

This project is designed to move sorghum and millet production technologies onto farmers' fields, link farmers' organization w with food and feed processors and to commercialize processing technologies sol as to enhance markets. To achieve this we improve the supply chain form the farm level to the consumer. The project emphasis in the north is on the development and transfer of décrue sorghum and millet technology while in the south the transfer of rain fed sorghum and millet te3cnhnology to the farm level.

Objectives:

- **Facilitate adoption of production and marketing technologies to improve the incomes of sorghum and millet producers**
- **Facilitate the development of markets for the use of millet and sorghum as a food for humans and as a feed for poultry**
- **Develop stronger farmers' groups and enhance their marketing power**
- **Extend mechanized food processing technologies to entrepreneurs and processor groups**
- **Introduce improved agronomic practices into décrue farming systems in northern Mali.**

Implementing Partners:

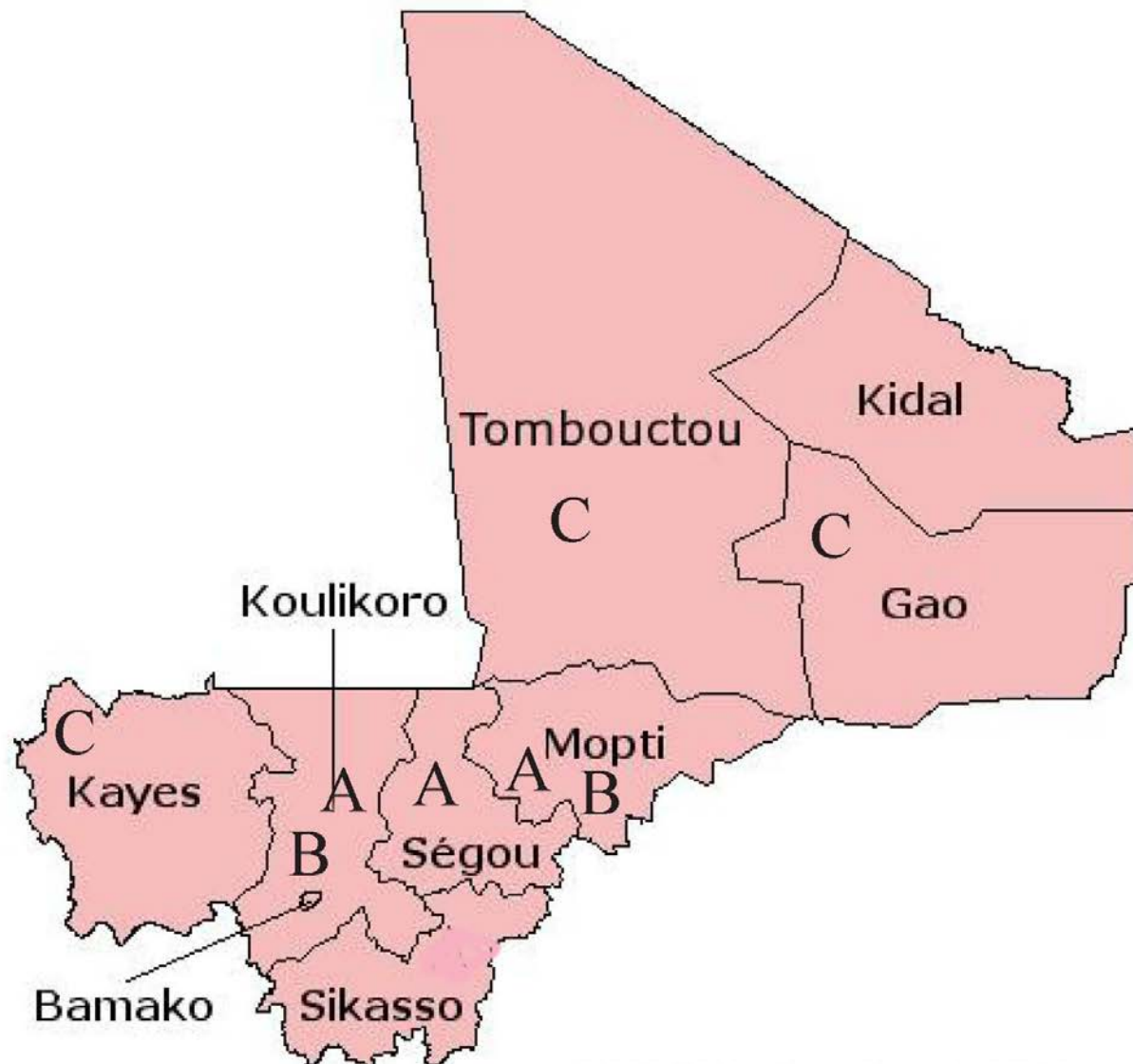
Africare**	NGO
AMEDD**	Association Malienne d'Eveil au Developpement
BNDA**	Banque Nationale de développement Agricole Mali

CONFIGES**	NGO/ Gao
CRRRA**	Centre regional de Recherche Agronomique
DRA**	Division de la Recherche Agronomique
IER*	Institut d'Economie Rurale
KSU*	Kansas State University
IICEM**	Integrated Initiatives for Economic Growth In Mali
Purdue*	Purdue University
RCGOP**	NGO/ Tomboctou
SAA**	Sasakawa Foundation
WTAMU**	West Texas A&M University

*Prime partner

**Sub-prime partner

Geographic areas of coverage:



INTSORMIL Projects in Mali

A = Production and Marketing

B = Food Processing

C = Décrué Sorghum

3. Executive Summary of Achievements

There is an increasing level of integration between the three principal activities of the broader INTSORMIL Project and this level will be intensified further in 2012. With the food processing sector, **Production-Marketing** continues to advise them about the increasing availability of clean seed from our farmers' associations and the need of our farmers' associations for a price premium for quality. We also hold joint workshops of processors and farmers' associations to help build these commercial networks. Due to the lack of available technologies for décrué sorghum production the KSU program has emphasized research activities. Now that they have identified technologies that function well on the décrué, Production-Marketing will be collaborating with them to get the technology out to farmers following the integrated extension approach that Production-Marketing has been introducing. This will be operational in Kayes and Mopti in the 2012 agricultural year. The next step is to plug the KSU décrué sorghum program into the IICEM operation to increase the hectares of décrué sorghum under improved technologies/management practices.

The Production-Marketing program is also tied to the overall INTSORMIL program from which we draw scientific help. We have had visits combined with short courses for intensive chicken producers by Joe Hancock, animal nutrition scientist specializing in poultry at KSU. As we get yields of sorghum up we can compete with corn in the rations especially for intensive poultry. Non-tannin sorghum have 95 to 97% of the feeding efficiency of maize so with prices at 95% or less of maize producers should substitute sorghum for maize in the ration. Chicken producers or feed mixers need the mixing machine to do this and the awareness of the substitutability between rations. Joe Hancock provides the necessary technical information and has been doing this for several years supporting our program. The intensive poultry sector is growing rapidly. With good yields of Grinkan in 2012 we will be again competing with maize with respect to price as was the case in 2008. So we will need to follow up our workshops and advise chicken producers about relative prices at that time.

Décrué sorghum project activities include 1) Expansion of the sorghum varieties Saba Tienda and Saba Sôtô with more farmers involved in other regions of the décrué system, 2) Introduction of new cultivars in Gao, Mopti and Kayes through an adaptation test, 3) Training on insect identification and pest management for all technicians involved in extension and research of the décrué system, 4) A better understanding of the response to fertilizer of sorghum, through soil and plant analysis from experiments conducted in the décrué systems and a BMP (Best Management Practices) package for décrué sorghum developed. Technologies made available to farmers are a new cultivar, moderate inorganic fertilizers and improved agronomic practices. Next year we will expand the program with participation of more farmers and start creating farmers groups to expand area under cultivation.

Food Processing project activities focused on 1) further building capacity and providing technical support to entrepreneur partners in the Mopti/Gao region of northern Mali, and 2) completion, testing and final work on the Incubation Center at IER Sotuba in Bamako. These two parts of the Processing Project comprise activities in Mali concentrated on expanding markets for sorghum and millet. Other related work relates to INTSORMIL training activities for Ms. Fatima Cissé, M.S. student at Purdue University who spent 3 months in Bamako conducting part of her research thesis work. Processors in the Mopti/Gao region are now generally functioning in terms of processing milled products that are being sold into the marketplace. The Incubation Center (IER Sotuba) building and milling and agglomeration and drying equipment was fully functional in June 2011. During the summer equipment was tested and procedures were further developed for processing of products. **Over the summer quarter, final items were completed for the formal launch of the Center at October end.** Since the inauguration we have demonstrated the functioning of the Incubation Center in providing technical support for processing of quality competitive products.

Year 2010-2011 targets were met with 972 additional ha under improved technologies and 1320 farmers adopting new technologies or management practices. Targets for 2012, providing receipt of requested funding, include 1) Area in new technologies = 1500, 2) Beneficiaries= 1840 men+160 women, 3) New Farmers' Associations= 20, and 4) Food Processors involved in post-harvest activities= 20.

The **training component** is managed Purdue University. This component is based on the need for competent technically qualified scientists in sorghum and miller food processing, agronomy, and agricultural economics in Mali. Five students were selected by IER for degree training in the USA. Two are currently studying economics at West Texas A&M; two are in agronomy in Kansas State University under Prof. Vara Prasad and one is at Purdue in Food Science under Prof. Hamaker. Two have completed short term training; one in agronomy under Prof. Prasad at KSU and another in breeding under Prof. Mitch Tuinstra at Purdue University. Abdoul Wahab Toure completed a short term training program at Kansas State University where he conducted studies on the mechanics of drought tolerance characteristics of *décrué* sorghum cultivars.

4. Project component description and intermediate results

The **production-marketing** activities are led by John Sanders (Purdue University) and Botorou Ouendeba (Consultant/Niger). There are three principal activities of this project: first, expanding the on-farm activities. This includes the diffusion of new technologies and marketing strategies to farmers and developing farmers' associations; second, documenting effects of the program and doing the background studies to facilitate the marketing strategy focus of the project; third, training of Malians to take over the project and to provide inputs into the monitoring and development of IER and other national agency staff.

The team is implementing a system including technology introduction, development of farmer groups, marketing strategy innovation, and linking of farmer groups to food and feed processors. This system is functioning well in southern Mali and activities there will be continued and expanded. But the main thrust is to move the project further north into *décrué* sorghum regions and into more marginal millet regions.

This activity draws on the expertise of INTSORMIL scientists in its technology development, extension and marketing activities. Activities are conducted in collaboration with the main agricultural research agency in Mali, the IER (Gao-based scientists in the north), the AEG (Ministry of Agriculture and Extension), local NGOs in Koutiala and Tingoni and various extension-development organizations, various farmer associations, millet processors and intensive poultry producers.

This project starts with the farmers getting technologies onto their fields. The new technologies include new cultivars, moderate levels of inorganic fertilizers, water harvesting techniques, and other agronomic improvements. IER and NGOs, such as Global 2000 and AMEDD, work with the project in the delivery of the technologies and the monitoring of the farmers. The seeds and fertilizer are paid for by the Production-Marketing Program and provided as input credits to farmers. Another critical input provided is the tarps (see photo) to get the threshing off the ground and thereby produce cleaner grain for the processors. The input credits for the seed and the inorganic fertilizers must then be repaid to the farmers' association in grain at harvest. The farmers' association makes a profit from the cleaner grain and the higher prices from selling later in the year. With the credit repayment and the profits from cleaner grain and better marketing the farmers' association then has a rotating fund for input purchase, expansion of membership, and inventory credit. Simultaneously they also regionally test new cultivars from the national breeders in this process. Once the new cultivar has been introduced in the first year of the program they work with local farmers and the farmers' organization to produce seed for succeeding years in the region. This requires training local farmers in the principles of isolation and roguing. Roguing is an especially difficult concept because the new cultivars are generally of medium height and farmers traditionally select the taller, hardier cultivars. Once farmers understand the concept of selecting for fewer stalks and more grain, this process works fine.

The basic premise of this program was that substantial new technologies exist for these crops. These technologies include new cultivars, moderate inorganic fertilization, and improved agronomic practices. What has been lacking has been a concern with and strategy to respond to the three principal price collapses reducing the profitability of these basic staples. Prices collapse at harvest as farmers are pressed to make a series of expenditures at that time. Prices collapse in good and sometimes even normal years as there is just so much of the staples that people can eat so new markets to put floors under staple prices or to provide value added are needed. Finally, governments often intervene in bad rainfall years when prices start going up with food aid or subsidized food imports. Putting short run consumer interests over those of producers can have a long run deleterious effect on farmers' incentives to use inputs and to make investments in their agricultural activities. So with our marketing strategies we operate on as many of these price collapses as possible. The consequence is that we increase the profitability of farmers' investments in increased input use. Not using enough inorganic fertilizer is similar to telling poor people that they should eat less. Plant nutrients are essential to any strategy to increase yields.

Our principal intermediate results are to get technologies onto farmers' fields, introduce marketing strategies and develop new farmers' associations. The ultimate objectives are to raise farmers' incomes, develop and extend methods to move technology more quickly from the experiment station to farmers, and facilitate the links of farmers back to the experiment stations so that researchers respond more rapidly to pressing field problems.

The **Food Processing Project** is led by Prof. Bruce Hamaker of Purdue University. The overall goal of the cereal **processing technology and training** component of the project is to establish a successful model of entrepreneurial processing of competitive millet and sorghum food products for expansion of the grains in the marketplace. The project is managed out of IER/Sotuba by Yara Kouriesi and recently the project hired two young food technologists, one located in Sévaré to work with processors in the Mopti/Gao region and one located at IER/Sotuba to work at the Incubation Center. Our cereal processing technology consultant, Mr. Mamadou Diouf, has extensive expertise and experience in sorghum/millet processing and working with entrepreneurs.

Processors in the Mopti/Gao region are now generally functioning in terms of processing milled products that are being sold into the marketplace. We have a full-time food technologist, Niamba Fousseyni, who resides in Sévaré, the adjacent town to Mopti where our entrepreneur partners have their processing units. Niamba has played the critical role of working constantly with the processing units, in Sévaré as well on a monthly basis in Gao.

The **décrue sorghum** activities are led by Vara Prasad and Scott Staggenborg, Kansas State University, Mamadou Diourte, Sorghum Program Leader, IER, Sotuba, Abdoul Wahab, IER, Traore, IER Sotuba and Samba Traore, Agronomist and Director of the Cinzana Research station of IER. Activities are conducted in collaboration with the sorghum program scientists from IER, Sotuba. The goal is to identify agronomic practices that lead to increased yields and increased quality of post water recession grown sorghum. Activities to be conducted by IER scientists include cultivar collections and testing to identify most suitable cultivars for the region, testing of various cultural practices (cultivars, planting techniques, fertilizer regimes, pest management strategies including weeds, insects and plant diseases), and transfer of suitable technologies identified to farmers. The global objective is to generate improved agronomic techniques along with appropriate décrue sorghum cultivars to sustain food production and foster economic improvement of northern Mali. The following is a brief description of the intermediate and anticipated results.

- **Genotype Screening:** Several genotypes were screened at multiple sites under the décrue production system. Genotype Saba Soto and Saba Tienda yielded best in the multi-location test. However, the grain quality of these genotypes needs further improvement. Genotype Niatichama, despite its improved grain quality, was poorly adapted to décrue production systems and yielded poorly in a dry year and was more susceptible to diseases. Farmers in most regions showed interest in producing Saba Soto or Saba Tienda. We are in the process of

developing a seed production system for these two genotypes. We intend to multiply and expand the area under these two cultivars in the northern region in the next two years.

- **Crop Management Studies:** Increasing planting density (decreasing plant spacing) showed yield benefits across the regions. These yield benefits were mostly related to a greater number of productive tillers and improved resource utilization. Fertilizer management studies showed positive responses in a few sites (Lake Horo) where nutrients N and P were found to be deficient. There was a limited or no response in some sites (particularly Lake Faguibine). This limited response could be due to low land areas. More research is needed in the highlands. There is a need to critically evaluate décrue soil for nutrients and identify regions where fertilizer management can form part of the management package. In addition to nitrogen, some regions were deficient in phosphorus, thus both should also form the part of management package.
- **Pest Management:** The sorghum crop was highly sensitive to insects and diseases during early season and also during grain filling period. Most of the genotypes responded positively to seed treatment. There was a significant increase in the number of plants and increased grain yield. Research is in progress on identification of various insect pests and plant diseases to develop an effective pest management schedule.
- **Diffusion of Integrated Crop Management Practices:** Our research has shown that use of integrated package of adapted genotypes (e.g. Saba Soto, Saba Tienda, Saba Albakari) seeds treated with fungicide and planted at a spacing of 0.8 x 0.6 m, with a fertilizer application of (Urea or DAP) will improve grain yield by >30% across most décrue sites. We will test these packages in more areas in the Mopti and Kayes region in 2012.

The **training component** is led by Prof. Jess Lowenberg-DeBoer of Purdue University. This component is based on the need for competent technically qualified scientists in sorghum and miller food processing, agronomy, and agricultural economics in Mali. Five students were selected by IER for degree training in the USA. Two are currently studying economics at West Texas A&M (did not meet the entrance requirements for Purdue University); two are in agronomy in Kansas State University under Prof. Vara Prasad and one is at Purdue in Food Science under Prof. Hamaker. Two have completed short term training; one in agronomy under Prof. Prasad at KSU and another in breeding under Prof. Mitch Tuinstra at Purdue University.

5. Achievements during reporting period

Production – Marketing: John Sanders, Purdue University and Botorou Ouendeba

Mopti- 250 new ha for men and 90 ha for women in seven different villages. With the revolving fund from previous years this makes 760 ha in the new technology. Seven farmers' associations are building up their storage capacity with our inputs this year. We continue to work with these sites to develop the marketing strategies. The development of storage capacity and confidence in the farmers' associations is critical for increased bargaining power for these associations. Mopti is known for its cleaner millet as women do the traditional pounding here. With higher yields from the program new threshing methods will be needed. But farmers also need to know that they will get a quality premium so we are working on both sides of this now.

Koutiala- With the seed quality problems with Grinkan we concentrated on seed production in 2011 on 12 ha. With good yields and germination we will put up to 1000 ha into the field in 2012 in this region. We have demonstrated Grinkan in both Burkina Faso (2010) and Niger (2011) and farmers in both countries are very anxious to expand the area in Grinkan.

Segou-With substantial inputs from Sasakawa and the DRA of Segou the area in new technology was increased by 500 ha with 17 new farmers' associations. Combined with the 494 ha increase in 2010 this is almost a 1,000 ha increase in the new technologies with 27 (10 from the 2010 program) new farmers' associations. Clean millet production in the Segou region is very important to the future evolution of the millet processing industry in Bamako. Millet processed products have become much more important in the urban food diet and have the potential to grow even faster as the regular supply of increasing quantities of clean millet can be provided. We held a workshop of millet processors and the representatives of the farmers' associations from this region in 2010 and emphasize these links in our interactions with farmers and the DRA in our field meetings.

Kayes and Koulikoro- M. Diourte took the lead in getting two new sites involved in our new technology program with progeny from Grinkan. This included 100 ha for men and 20 ha for women. The yield results reported by Diourte and Teme were excellent. We will be working with them on storage and marketing issues in our December visit.

Summary- Our principal focus is on the Mopti and Koutiala (Sikasso) regions but Segou has the most potential to be a catalyst for the rapid development of the millet processing industry in Bamako so we need to develop these networks between the farmers' associations and the millet processor firms in Bamako. In 2012 the area expansion in Koutiala with good seed of Grinkan will be a principal activity as will the further development of the over 1000 ha in Mopti with their improved storage and better marketing practices. We also will continue to collaborate with IER in their activities outside our primary regions.

Food Processing: Bruce Hamaker and Fatima Cissé, Purdue; Yara Koreissi, IER/LTA; Mamadou Diouff, Consultant

This year the Processing Project had activities focused on 1) further building capacity and providing technical support to entrepreneur partners in the Mopti/Gao region of northern Mali, and 2) completing the testing and final work on the Incubation Center at IER Sotuba in Bamako. These two parts of the Food Processing Project comprise activities in Mali concentrated on expanding markets for sorghum and millet. Other related work this year relates to INTSORMIL training activities for Ms. Fatima Cissé, M.S. student at Purdue University who spent 3 months in Bamako conducting part of her research thesis work that is described below.

Component 1 –Mopti/Gao region entrepreneur partners

Processors in the Mopti/Gao region are now generally functioning in terms of processing milled products that are being sold into the marketplace. We have a full-time food technologist, Niamba Fousseyni, who resides in Sévaré, the adjacent town to Mopti where our entrepreneur partners have their processing units. Niamba has played the critical role of working constantly with the processing units, in Sévaré as well on a monthly basis in Gao. Activities for the year have included:

During the third quarter Yara Koréissi Dembélé and three technicians from IER/LTA travelled to Gao, Mopti, Sevare and Bandiagara. The objective of this trip was to train further workers on processing equipment (one day in each unit) on how to operate and maintain the machines before and after each processing run, and how to follow/document the production of the processing units. Grain was purchased from farmers working with the team of the production-marketing project in Koutiala, Douentza and N'Garasso. Generally, quality was good for the processing units and further purchases have been sought. Two aspects of quality of grain are important to the processors to make high quality products, grain cleanliness and homogeneity of grain size. The latter factor affects ability to decorticate grains evenly and make high quality flours both for direct sale and for processing to other products. Communication from processors to farmers is important and has been established from the production-marketing project to build sustaining links between these two players in the supply chain.

Bruce Hamaker and Mamadou Diouf worked in Bamako and traveled to Sévaré and Bandiagara to work with entrepreneur partners during the period April 24 to 29, and M. Diouf thereafter traveled to Gao. During this trip, assessments were made on processing units and minor issues to be resolved for full engagement in processing activities. A meeting with USAID/Mali officials during this trip highlighted other issues to consider in the Mopti/Gao region project such as switching diesel engines for electric where desirable (due to the rapid rise in diesel prices), effective marketing as well as market assessment of processed products, and potential for incorporation of micronutrient fortification activities. We have investigated using electric motors opposed to diesel, found them to be reasonable in cost, and have discussed with our partners for change in the next few months

The processing team from IER/Sotuba visited the major sites (Sévaré/Mopti, Bandiagara and Gao) of our activities July 24 to 30. The objective of this visit was to monitor and supervise the movement of previous stocks of grains procured for the processors mainly from farmer's groups from the Production/Marketing portion of the overall project, and to facilitate renewal of the stock where necessary. The processing units had finished the old stock, and some had renewed it themselves, while others had not. A new grain stock of 14 tons of millet was made available, for payment, for the Mopti and Gao processors to have good and clean grain for processing. It is quite clear that it is critical to procure sufficient high quality grains for processing to make competitive products for the marketplace.

From September 24 to 30, our consultant, Mamadou Diouf from ITA/Dakar, and the LTA team visited Sevaré/Mopti and Gao. Entrepreneur partners and their staff were trained in good manufacturing practices including sanitation similar to the hazard analysis and critical control points (HACCP) approach used in the US. Documentation methods were stressed including how to fill the technical documents as well as to record amounts of products processed and sold. Stocks of grain were again evaluated and arranging for sources of high quality grains were discussed, so that at project completion that a system is in place to obtain such grains. During the trip, the INTSORMIL processing team had a meeting with IICEM/Mopti to exchange information on the activities of both project.

This visit was also made to monitor the state of the functioning of machines, and the building of minor outside shelters in two of the units and other minor complementary work for the improvement of working conditions in the units. An arrangement was made for a local mechanic to be available for equipment maintenance in Sévaré. Likewise, a resource person has been identified in Gao for mechanical issues of the processing units.

Niamba Fousseyni, the INTSORMIL project technician for Mopti/Gao moved to a new apartment that now acts also as our extension center for activities in the Mopti area. Niamba reports that, in general, the units are working very well, though small problems persist in some processing units and thorough documentation at each unit by our processor partners is still an issue in some units.

After meeting and agreement with beneficiaries in Mopti/Gao (and Bamako), the entrepreneur partners will participate in the FEBAK 2011 (Foire exposition de Bamako) in November. This participation will be benefit to them to exchange experiences with processors in other localities and to have new contacts.

Component 2 - IER/LTA Incubation Centre

The Incubation Center building and milling and agglomeration and drying equipment was fully functional in June 2011. On July 12 a trip was made to Kafara to discuss and negotiate with farmers to get a stock of good and clean grain of sorghum (SEWA variety) to test the performance of equipment in the Incubation Center. From this trip a stock of 500 kg of sorghum was bought from the farmer's association and brought to IER/LTA for the testing at the Incubation Center. Our principal focus during the last quarter was to test the performance of the equipment in the Incubation Center using the 500 kg of sorghum (Sewa variety) as mentioned above. Overall, the agglomerator is working very well and properly for the *couscous* and *degue*, but not for the *moni kuru* (main dish for breakfast

Then we conducted a demonstration and training workshop for Bamako area processors and our Mopti/Gao entrepreneur partners. It was emphasized that success for the project will be assessed by demonstration of a sustaining successful model where entrepreneurs are able to process grains into high and consistent quality products that have

good and continuing sales in the marketplace, and where grain purchases are made from farmers or farmer's groups that supply high quality grains to processors. Over the summer quarter, final items were completed for our end of October formal launch of the Center. Also during this time, equipment was tested and procedures were further developed for processing of products. We identified two Bamako area processors to work with and have installed two processing equipment pieces in these two units, with a repayment scheme similar to that used with the Mopti/Gao entrepreneurs. Since the inauguration we have demonstrates the functioning of the Incubation Center in providing technical support and further process refinement with processors for processing of quality competitive products.

Thesis Research Project of Fatima Cissé

A portion of Fatima Cissé's research project at Purdue University involves collecting data on nutritional/health attributes of traditionally made foods from millet and sorghum that may make them desirable to buy and consume compared to imported grains and tubers used in urban areas of Mali. Our goal is to understand whether and how millet and sorghum foods may be promoted to urban consumers for market expansion for local farmers. In a previous study conducted by us in the fall of 2010, we found that at the village level, in three regions (Segou, Mopti, Sikasso), participants preferred thicker porridges (tô) compared to urban consumers and that thicker porridges were significantly more satiating (less hunger feeling at 4 hours after consumption). In the present study, Fatima used a ¹³C-breath test (stable, safe isotope of carbon that is naturally found in foods) to evaluate gastric emptying rate of traditional and imported foods for Bamako consumers. Rapid gastric emptying of starchy foods generally results in high glycemic response and may relate to feeling of fullness and caloric intake related to obesity. It should be noted that hunger feeling and consumption patterns of food are multi-factored events. Still, large differences in gastric emptying rates may be related to healthiness of foods. Eight foods were evaluated [rice, potatoes, pasta, thick millet and sorghum porridges, thin millet porridges with and without *moni kuru* (particulates), and millet couscous]. Gastric emptying rates of the foods were substantially different and grouped as follows: rice > potatoes, pasta > thin porridges > thick porridges > couscous. Thus, newer "imported" foods overall had faster gastric emptying rates than the traditional millet and sorghum foods. Results will be published in a peer reviewed journal.

Décrué Sorghum: Scott Staggenborg and Vara Prasad, Kansas State University and Abdoul Wahab Toure, IER, Mali

Cultivar development

- Saba Sôtô and Saba Tienda have been selected as the most promising cultivars for the décrue system because of their yields and preferences by women for threshing and food purposes. However, both lack sufficient grain quality and thus IER is crossing Saba Sôtô and Saba Tienda with cultivars reported for to have excellent grain quality. The third generation of improvement has been completed. More than 1,000 samples have been sent by Malian agronomists for physical and chemical analysis.

Cultivar Evaluation

- From a preliminary screening of 50 cultivar tested in Gao (in the décrue area), in Mopti (on station) and Kayes (décrue area) as based on the participative approach, the following genotypes were selected by farmers in: Saba Sôto Koreye, Saba Albakari, Saba Sôto Kara, Saba Sôtô Tienda, 05-SB-DU-135, 05-SB-DU-119, CSM 63 and 08-KO-DU-111. Among the cultivars selected by farmers, Saba Sôtô, Saba Tienda and Niaticama were the highest yielding.

- The demonstration plots showed superior adaptability of varieties Saba Soto and Saba Tienda when compared to Niaticama in the décrue production systems in northern regions of Mali (Tomboctolu). Niaticama, although its grain quality well appreciated by women, appeared to be less adapted to the décrue system, compared to Saba Sôtô and Saba Tienda, the local cultivars. There is a need to test more genotypes for yield stability and grain quality in this region.
- We are expanding the area of the selected cultivars to farmers in other areas of the décrue system including the Ago, Mopti and Kayes Regions.

Soil nutrient deficiencies study

- The response of sorghum to fertilizer depended upon the soil type and location. In poor soils such as those in Tonka, the sorghum crop responds to nutrients. Maximum decreases in grain yield were observed when N or P were deficient.
- Using chemical fertilizer increased grain yield in few locations in Lake Horo, but not in Lake Faguibine sites
- P and N were deficient nutrients in soils in the Horo lake area and the sorghum plants responded positively to the addition of inorganic fertilizer.
- There is need for soil testing prior to planting to determine the benefits of inorganic fertilizer. In addition more research is needed in the highlands which generally have poor soils.

Training of technicians

- Technicians involved in the décrue system research and technology transfer program received training on insect diagnostics and on the integrated management of sorghum insect pests. More than 20 research and extension technicians were trained.

Training: Jess Lowenberg-DeBoer, Purdue University

Short term training

Abdoul Wahab Toure was a research scholar in crop physiology and production laboratory at Kansas State University August – September, 2011. He participated in ongoing field research activities on sorghum and soybean. He also initiated a controlled environment research experiment to understand the root growth of various crops including the sorghum genotypes from the décrue region in Mali. The objectives of his research were (a) to assess differences between crop species based on root parameters; and (b) to assess differences within crop species based on root parameters. Different crop species involved sorghum, corn, wheat and millet under full irrigation and drought stress condition. These experiments are set in controlled environment conditions in green houses. There were two experiments, the first to be harvested after two weeks of stress and quantify effects during early seedling stages; and second experiments to see the effects at late vegetative or reproductive stages of crop development. The first experiment was harvested in late September and data was collected on root traits using root scanner and WinRhizo software. Significant results were obtained. Varieties Saba Soto and Saba Tienda which do well under drought conditions in the décrue system had much more extensive root systems than varieties which are not drought tolerant (see “Success Story below).



Mr. Abdoul Wahab Toure preparing root samples for scanning.



Mr. Abdoul Wahab Toure measuring root traits of sorghum plants

Long term training

We have five long-term academic students from Mali studying the US and as of June 2011, all are enrolled in their respective Master's graduate programs. Their graduate school admission dates varied from January 2010 to June 2011, due to English language skill performance.

Fatimata Cisse (Purdue Food Science) has successfully completed five semesters of coursework and her eight-week research visit to Mali to collect her data. In addition to one course, she is entering and analyzing her data and preparing another experiment. She will need to extend her training program to June 2012 to complete her MS degree. However, Bruce Hamaker, her major professor, would like to change Ms. Cisse's training to a PhD program if possible. He is in discussions with the Food Science Graduate Committee regarding this bypass from a master's to a doctorate program and has discussed this with the ME and IER. If approved, the additional costs to complete her PhD training are proposed to be supported by other INTSORMIL funds, and would require her program to be extended to June 2013.

Sory Diallo and Bandiougou Diawara continued their Master's coursework in Agronomy at Kansas State University. Mr. Diawara completed his fourth semester and Mr. Diallo finished his first. Both are working hard on their coursework and are progressing on their research which will be performed in the US.

Mr. Sory Diallo conducted field studies to understand the effect of nitrogen on grain quality of different sorghum genotypes. The objectives of his research were (a) to determine the effect of different levels of nitrogen application (0, 40, and 80 kg ha⁻¹) on grain quality of sorghum; and (b) to evaluate grain traits: kernel hardness, kernel mould, starch content and crude protein content across the sorghum diversity panel. In this study different levels of nitrogen (0, 40, and 80 kg ha⁻¹) are being examined. In summer 2010, a two-year study was initiated to determine the effect of nitrogen levels on grain quality of sorghum. The field experiment was conducted in Kansas, Manhattan, Ottawa, and Hays in 2010 and the same experiment was planted in summer 2011. Treatments consisted of twelve genotypes (six sorghum hybrids and six sorghum inbred lines) and three fertilizer levels (0, 40, 80 kg ha⁻¹ with the N fertilizer urea). Experiment was laid out as a randomized complete block design with four replications. At maturity the central four rows of each plot were harvested and threshed separately for obtaining the data of grain yield and grain quality analysis. The grain samples of 2010 experiment are currently being analyzed for grain quality at USDA laboratory. The focus is on kernel weight, kernel crude protein content, kernel hardness and diameter. The results of the experiment from this summer (2011) are currently being analyzed.



Graduate student Mr. Sory Diallo in his sorghum field at Manhattan



Mr. Sory Diallo establishing field plots in Kansas.

Mr. Bandiougou Diawara worked on his research project and at the same time taking academic classes. The main objectives of his thesis research are (a) to understand the impact of early planting on growth and yield of sorghum and (b) to understand response of selected sorghum hybrids to early planting. The study consisted of two planting dates, three hybrids and two locations. There were two planting dates, first in late May and second in late June. During the plant growing period, data on leaf area was measured at six leaf stage, at anthesis, and at physiological maturity for each plot. The plots for the first planting date in Manhattan were harvested and threshed. Yield, yield component, dry matter production, and partitioning were measured at maturity. The data is currently being analyzed. Due to the extremely dry and hot weather this season, experiment in Hutchinson had poor germination and poor crop development. In addition, to research he did his literature review, data analyses from last harvest and prepared a poster for presentation (posted on INTSORMIL website). In addition to his research Bandiougou is working with other students in crop production laboratory to learn field techniques and data collection. These projects mainly include biofuel demonstration plots, evaluation of drip irrigation systems, and soil erosion experiments.



Bandiougou Diawara in field at Manhattan

Bandiougou Diawara conducting leaf area analyses with a leaf area meter

Aly Ahamadou and Mamadou Dembele were accepted June 1, 2011 into the West Texas A&M's Graduate School to pursue their non-thesis Master's degree in Business and Economics in the Department of Agricultural Sciences. Dr. Lal Almas, their major professor, reports both students performed well this summer. They have already completed three hours towards their degree and three hours for research is in progress. Both have submitted selected paper proposals/abstracts for presentation in the Southern Agricultural Economics Association annual meetings to be held in February 2012 in Birmingham, AL. They are required to submit the full papers (20 pages) by January 17, 2012 if their papers are accepted for presentation. Currently they are enrolled for nine hours of coursework and are making good progress towards their degree program.

6. Indicators

EG Strategic Objective:

Accelerated Economic Growth

To strengthen agriculture's contribution to broad-based economic growth, better health and effective natural resources management

Program Element:

Agricultural Sector Productivity

Encourage economic policies and strengthen institutional capacity to promote broad-based growth

Project indicators/ targets 1-3:

Number of new technologies made available for testing, transfer and adoption by farmers

Project indicators/ target 4:

Number of additional hectares under improved technologies or management

Project indicators/ target 5:

Number of individuals who have received INTSORMIL supported short-term training

Project indicators/ target 6:

Number of businesses/ individuals involved in any form of post harvest activity

Activity 1:

Improving the efficiency of input markets for millet and sorghum and introducing better marketing strategies combined with new technologies

Activity 2:

Develop sorghum production technology for the "culture décruée" system

Activity 3:

Developing alternative markets for sorghum and pearl millet grain by developing and transferring new food processing technologies to entrepreneurs

How these indicators and targets lead to achievement of the EG strategic objective, Accelerated Economic Growth.

The (1) activities, (2) project indicators and targets and the (3) program element all lead directly to the achievement of the strategic objective, *“to strengthen agriculture’s contribution to broad-based economic growth, better health and effective natural resources management.”*

Activity 1 is the main focus of the Production-Marketing project. In 2009 there were numerous successes in southern Mali especially in the Koutiala region with the sorghum cultivar Grinkan and in the Segou region with the millet cultivar Toroniou as we extended our cultivated area to almost 1,000 in the pilot project phase. In 2010 we collaborated with IICEM in scaling up our operation. IICEM became responsible for the implementation and financing of this scaling up of our model activities. Production-Marketing and Processing are the technical advisers to this development project of IICEM. In 2010 the combined effort reached almost 2,500 ha. We are discussing a major increase in 2011.

Activity 2 offers applied research and extension support for a potentially important production activity in the northern region and in the Kayes region. In 2011 this project will work more in combination with the Production-Marketing project as both extend their activities into Kayes. Décrue sorghum has substantial potential for increasing farmers’ incomes and welfare and has been largely ignored in the past.

Activity 3 has two important components. Production-Marketing will continue to do market studies of millet food processing and the intensive poultry sectors (for sorghum substitution for maize in the ration). Moreover, we will facilitate ties between these markets and our farmers’ associations with workshops and with training to the farmers’ associations in marketing arrangements. The Food Processing project is providing mentoring and machinery to several millet processing entrepreneurs in the northern region. With the machinery Food Processing sets up incubator or model processing operations, which a larger sector of new processors can imitate.

Indicators	Year 1 2008 Crop year	Year 2 2009 Crop year	Year 3 2010 Crop year	Year 4 2011 Crop year	Target 2012 Crop year
1. Number of new technologies or management practices under field testing as a result of USG assistance.	5	6	8	10	6
2. Number of new technologies or management practices made available for transfer as a result of USG assistance.	5	6	7	6	6
3. Number of additional hectares under improved technologies or management practices as a result of USG assistance.	500	984	894	972*	1500
4. Number of individuals who have received USG-supported short-term agricultural sector productivity training.	500 (ca 450 males and	800 (ca 650	1,150 (ca 1058	1,320 (ca 1214	2000 (ca 1840

	50 females)	males and 150 females)	males and 92 females)	males and 106 females)	males and 160 females)
5. Number of individuals who have received USG-supported long-term agricultural sector productivity training.	0	4	5	5	5
6. Number of farmers adopting new technologies or management practices.	500 (approximately 450 male and 50 female)	800 (approximately 650 males and 150 females)	1,150	1,320	2000
7. Number of processors or businesses/individuals involved in any form or post harvest activity. (5% male and 95% female)	6	8	18	20	18
		Crop Year 2009	Crop Year 2010	Crop Year 2011	Target 2012 Crop year
IEHA: Number of Farmers/producers or processors adopting new technologies. Relevant technologies include:					
8. - Mechanical and physical: new land preparation, harvesting, processing and product handling technologies including packaging		984	1,150	1,320	2000
9. - Biological: new germplasm that could be higher-yielding or higher in nutritional content, affordable food-based nutritional supplementation such as vitamin A-rich sweet potatoes or rice, or high-protein maize, or improved livestock breeds, and livestock health services and products such as vaccines		984	1,150	1,320	2000
10. IEHA: Vitamin A-rich sweet potatoes or rice, or high-protein maize, or improved livestock breeds, and livestock health services and products such as vaccines					

11. -Chemical: fertilizers, insecticides and pesticides	984	1,150	1,320	2000
12. - Management and cultural practices: information technology, improved agricultural production and marketing practices, better natural resource management practices.	984	1,150	1,320	2000

***Activities in 2011.** The focus was on the expansion of area in Segou (500 ha) and Mopti (340 ha). Another 120 ha were expanded by M. Diourte as part of this program in Koulikoro region. Only 12 ha was planted in the Koutiala region and for the Koutiala region in the experiment stations as there was a concentration on producing high quality seed of Grinkan in 2011.

Comments on the above Table:

Row 1. This comes from the Décrue sorghum field testing activities which increased with the inclusion of the Kayes region in 2011.

Row 2. Essentially the same activity is being introduced in all the regions, an improved cultivar, moderate fertilization, a water retention technique, and a series of improved agronomy techniques. We also recommend that farmers use organic fertilizers especially for the sandy soils where millet is concentrated. The differences in technologies are essentially from differences in cultivars. In the future we will adjust more the fertilization recommendation as we link our farmers' associations to soil testing services.

Row 3, 4, 6 and 8. As stated before we were asked in 2010 to collaborate with IICEM and our initial estimates included some of their area extension. But then we were requested by USAID to delete those estimates so as to avoid over counting. In 2010 and 2011 we expanded considerably in Segou with Global 2000 and in the Mopti region with DRA. We also incorporated many more women by limiting them only to the crop area over which they had control of the output.

Row 5. Long term trainees from IER in the US is constant at 5.

Row 7. Number of processors includes both the processors with which Production-Marketing works and those working with the Food Processing project.

Rows 8-12. This is essentially the number of new participants in the field operations.

7. Gender Related Achievements

Gender related achievements and how gender is mainstreamed into the activities- The land holding system in the Sahel is that the extended family farms together a communal area with the household head making the decisions on labor supply and product allocation. After the adult family members have provided their labor as specified by the household head, they can work the small area of private plot for themselves allocated each year to them by the household head. Women devote substantial efforts to these private plots but they are very small and often poor land far from the village. Women also have difficulty getting access to purchased inputs or to organic fertilizers, which are especially critical in the poor sandy soils on which millet is grown.

This project concentrates on the principal areas controlled by the household head but sets aside 10 ha for women for each 50 ha for the men. The specification is that the area of the women has to be from the private plots over which they control the output. Women cannot claim larger areas over which they lose control of the output as happened in the initial years of this project. Normally, the men have one ha, but each woman can have 0.25 ha so 40 women on the 10 ha allocated is common.

There are still various problems for the women. They usually are given the poorer land quality further from the village and have difficulty getting either the manure or organic fertilizer and the transportation for it. Since the women use more labor intensive practices and follow better the agronomic recommendations¹ than the men, it is very satisfying when the women's plots out yield the men's and we encourage the competition. Their repayment rates on the input credits are also higher than those of the men. In several villages in 2011 in the Mopti region we held the men at a constant area but increased the area for women due to the better performance of the women in repayment. We have also begun pressing in the villages for the women to have better land quality for their private plots and to have access to animals for seed-bed preparation. We also urge the men to make the compost and the carts (to transport manure to the field) available to the women.

Food Processors- Nearly all (95%) of the entrepreneur food processors we work with are women (in Mopti-Gao all are, and in Bamako most are). In this year, training in sanitation and quality of processed products was provided for our women entrepreneur partners in Mopti-Gao.

Training- Initially two of the five identified long term trainees were female, but one dropped out due to family issues and the USAID decision to not allow young children to accompany the trainees. However, one female trainee remained in the program and was the first to obtain the needed English skills (TOEFL score), the first to be accepted into a graduate program, and is now being considered for PhD rather than a Master's. This is both a gender achievement and a success story.

Preference for *décru* sorghum varieties- Women are involved in a participatory selection for grain quality and ease of threshing.

¹ The women are much more likely to do thinning and weeding on time than the men.

8. Synergic Activities

Production-Marketing

The entire program is synergistic. The Production-Marketing program started and is firmly rooted on defining the technologies with the national agricultural research organization (IER) and identifying the priority production regions with the national agricultural extension agency (DRA)

We collaborate with IER in getting their improved technologies into the field. Some of these technologies had been developed earlier with INTSORMIL collaboration. Then we rely on the DRA (national extension service) and several NGOs (Sasakawa and AMEDD) for the monitoring, input delivery, crop cuts and repeated interactions with the farmers' associations. We also develop ties with the private sector cereal buyers especially the millet food processors in the urban area and the emerging sector of intensive chicken producers (broilers and eggs with a focus on the former).

Our most important synergistic activity is with IICEM. USAID-Mali asked IICEM to scale up our technology project. IICEM has been concentrating on the financial aspects and farmers' associations have obtained substantial loans for millet and sorghum producers in various regions of the country principally from BNDA due to the IICEM intervention and loan guarantees. Besides technical support to IICEM we provided them with Toroniou certified seed in 2011 and will provide Grinkan seed to them in 2012.

We are also handling a series of issues on the technical pilot project side that will remain important to the scaling up of IICEM. These include the control of mildew in millet production with the appropriate fungicide, the future depletion of soil K with the continued fertilization with DAP, obtaining a price premium for the farmers' associations for the cleaner cereals, developing site specific fertilizer recommendations with increasing focus on soils laboratories and soil testing, developing the farmers' associations into functioning marketing coops, tying IER better into our farm level activities², improving repayment rates and farmer participation in the farmers' associations. Most of these things IICEM could not do at the same time that they are pushing for financing and a more rapid project expansion. However, a pilot project can do these activities and provide the results for the scaling up partner, IICEM.

Food Processing

For the food processing component the arranging for grain supplies from the production-marketing component of the project is an example of effective and productive synergy. We also hold joint workshops of processors and Production-Marketing farmers' associations to help build these commercial networks. In the project period, two meetings were held with IICEM at their office and B. Hamaker and M. Diouf visited with IICEM Moulin du Sahel to discuss future collaboration to facilitate larger industrial processing of sorghum and millet in Mali. Discussions are in progress regarding joint activities for assistance in industrial processing in the coming months.

INTSORMIL conducted a workshop to introduce and demonstrate new technologies for processing millet - and sorghum based products (agglomerated products). The workshop was held at the new incubation center set up by INTSORMIL and

² Demonstrations, the usual extension technique do not work well in the Sahelian countries. Farmers do not believe that they have the same access to inputs and techniques. With our village level technique best farmers follow the practices and then other farmers follow the next year.

IER at the Laboratory of Food Technology of the Institute for Rural Economy from June 21 to 23. The objective of the workshop was to introduce millet and sorghum processors and INTSORMIL's partners to new processing technologies to strengthen their ability to process market competitive sorghum and millet foods and to increase the quality and value of their product. The opening ceremony was done successively by the Director of CRRS Sotuba and the National Coordinator of INTSORMIL/ Mali on behalf of the US Coordinator who was stranded in Paris because of mechanical problems of the plane. Seven beneficiaries of INTSORMIL from Gao, Mopti and Bandiagara, 2 beneficiaries of INTSORMIL from AMTCL/ Bamako, 4 partners from IICEM millet and sorghum processors participated in the workshop. INTSORMIL as well as IICEM provide support to their partners and also to other participants.

Beyond this workshop, a small meeting was scheduled on 24th June only for INTSORMIL processing team and the seven beneficiaries from Gao, Mopti and Bandiagara. The objective of this meeting was to finalize and to sign the contract of retrocession (payback contract) on hand and to discuss and schedule for the supply of grains. Five contracts were signed.

Décrue sorghum

Synergistic Activities	U.S. Partners	Non-U.S. Partners	Details
<p>Technology development and transfer in the decrue area</p> <p>To identify performing</p>	<p>USAID-MALI for financial support</p> <p>INTSORMIL for scientific support in technology development for millet and sorghum.</p> <p>AGRA for financial support in hybrids development</p> <p>ICRISAT for regional approach in sorghum research within West Africa</p>	<p>-Regional direction of Agriculture for technology test and expansion: (Tombouctou, Gao, Mopti Kayes)</p> <p>- NGOs for technology test and expansion in Tomboctou and Gao regions</p> <p>Noragric for technology development, financial support in technology development focused on main decrue crops by year 2011</p> <p>IER sorghum breeder</p>	<p>Involvement of Noragric in financial support will give more opportunity to invest USAID money in providing more equipment to monitor water dynamics in the soil profile.</p>

<p>cultivars for sustainable production of sorghum in the décrue system using participative approach</p> <p>To determine soil nutrients deficiencies in the décrue system</p> <p>To diffuse integrated packages</p>		<p>and pathologist DRA Tombouctou, Gao and Mopti NGO CONFIGES NGO AFRICARE NGO RCGOP</p> <p>DRA Tombouctou, and Mopti</p> <p>DRA and NGO</p>	
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9. Other important activities

There is increasing collaboration between the three principal activities of the broader INTSORMIL Project. With the food processing sector, Production-Marketing continues to advise them about the increasing availability of clean seed from our farmers' associations and the need of our farmers' associations for a price premium for quality. We also hold joint workshops of processors and farmers' associations to help build these commercial networks.

With the décrue sorghum program, now that they have identified some technologies that function well on the décrue, Production-Marketing will be collaborating with them to get the technology out following the integrated extension approach that Production-Marketing has been introducing. This will be operational in Kayes and Mopti in the 2012 agricultural year.

The Production-Marketing program is also tied to the overall INTSORMIL program from which we draw scientific help. We have already mentioned the entomological help. We also have had visits combined with short courses for intensive chicken producers by Joe Hancock, animal nutrition scientist specializing in poultry at KSU. As we get yields of sorghum up we can compete with corn in the rations especially for intensive poultry. Non-tannin sorghum have 95 to 97% of the feeding efficiency of maize so with prices at 95% or less of maize producers should substitute sorghum for maize in the ration. Chicken producers or feed mixers need the mixing machine to do this and the awareness of the substitutability between rations. Joe Hancock provides the necessary technical information and has been doing this for several years supporting our program. The intensive poultry sector is growing rapidly. With good yields of Grinkan in 2012 we will be again competing with maize with respect to price as was the case in 2008. So we will need to follow up our workshops and advise chicken producers about relative prices at that time.

10. Problems, Challenges and Solutions

1. Sorghum and pearl millet yields in Mali

➤ Yield constraints to sorghum and millet production in Mali

The principal constraint to high yields is soil fertility. Hence our technology strategy is moderate inorganic fertilizer with water retention technologies to reduce the riskiness of fertilization and new cultivars to give higher yields without lodging. Note that water availability is also critical. There was too much rain in many regions in 2010 so sorghum which is planted primarily on the lowlands was adversely affected but millet grown on principally on the plateau and slopes had great yields. This year there has been a late lack of rain and in many regions another good rain is necessary for grain filling according to Ouendeba. In these years sorghum on the lowlands will do better and millet can be most adversely affected. Farmers are aware of these differences, have different methods of reducing risk and we also have a series of measures to handle risk built into the program.

The estimates of yields are preliminary from an experienced agronomist as it was still not harvest season when we made these estimates. From the field visits Botorou Ouendeba estimated that sorghum yields in our seed production plots would be approximately 2 t/ha. These are very good yields. Seed producers get a quality premium price so usually are careful to do the agronomy recommendations. Normally we are very happy with millet yields of 1.2 to 1.4 t/ha as millet is grown on poorer soils with lower soil fertility and often more water stress than sorghum. We observed very good millet fields in Segou and in Mopti and Ouendeba felt that if there was a little more rain in the grain filling stage there would be yields of 1.7 to 2 tons. This indicates good seed quality and excellent observance of the agronomic recommendations as well as using organic fertilizers.

➤ Yields of farmers that do not follow the recommendations

Farmers not in the program and not following recommendations in the Koutiala region but following the cotton rotation and therefore getting the residual effects of cotton fertilization (P) get 800 kg to a ton/ha of sorghum. Millet producers in the Segou region get 500 to 600 kg/ha and 400 to 500 kg/ha in the Mopti region.

➤ Barriers to technology adoption: What are farmers doing instead?

Why is there still substantial yield variation even though we are increasing substantially mean yields? Farmers need to follow the recommendations. With only moderate fertilization you have to make sure that the plants have access to it hence the importance of side dressing. There is resistance to side dressing of fertilizer and thinning because they are new practices and more labor intensive. Instead of side dressing, farmers often broadcast and often have their kids do the fertilization. Sometimes they do not cover the fertilizer and it volatilizes. Also, plant thinning is important but it is hard and farmers often have the erroneous idea that more plants and taller off types are better. We have run regressions on yields and both deviations (fertilizer and plant thinning) from recommendations have large yield costs. So we keep visiting them and going over the basic agronomical, marketing and organizational recommendations for the program

For this reason we introduce the technology to groups of farmers in the village. Sahelian farmers (that we know) do not believe in demonstration trials. They feel generally that this is something that is difficult for them to get all the inputs and practices together to do. But they do follow what other farmers are successful with. If 50 farmers adopt the technology in a village (and we try to get this number in each village where we start operating the program), 15 to 20

will follow well the recommendations in Year 1. In the second year, most of the farmers in the village will follow the recommendations.

2. Seed production

The main problem of the 2011 crop year was renewing the supply of high quality seed for our excellent cultivar, Grinkan. In the Koutiala cercle and in IER experiment stations we now have 12 ha in seed production of Grinkan from which we will obtain 12 to 18 tons of seed. Also good seed of the two progeny of Grinkan will be obtained from the sites of Kita and Beleco. So we will have sufficient seed for a substantial area expansion in Koutiala. We will need 8 tons of seed 1000 ha there in 2012. We will also be able to supply IICEM with substantial quantity of Grinkan and progeny seed.

3. Downy Mildew: impact on grain yield and its management

Downy mildew (*Sclerospora graminicola*) was observed to be a minor constraint in the Mopti Region this year. We estimate that yield losses were <5%. Downy mildew is the major disease of millet in West Africa and may affect all of the above-ground parts of the plant including the panicle and leaves (see symptoms in photos below). It is a seed transmitted disease and can have a devastating effect on grain yield. Yield losses due to this disease have been reported to range from 3.5 to 21% in Mali according to John Leslie (Sorghum and Millet Diseases, 2002).



Substantial work has been done in international centers looking for resistance and there have been good resistant varieties developed for India by David Andrews (formerly with INTSORMIL after his time in ICRISAT) and widely disseminated. The millet varieties introduced earlier in the region (ICRISAT-Sadore in Niger) were completely wiped out. We are using an integrated approach (tolerant improved cultivar + seed treatment) to prevent the

losses. The improved local cultivar (Toroniou) used in Segou and Mopti regions is tolerant to mildew but we recommend also the use of Apron Star (fungicide-insecticide) to treat the seed before planting. In Mopti region, the extension agent purchased in 2011 a cheap fungicide and the mildew infestation on the secondary tillers was around 5% (tolerant reaction).



We have explained to the farmers the seed transmission characteristic of downy mildew and the need to use the appropriate fungicide for the next crop. Here it should be pointed out that the failure of the extension service and the farmers to follow recommendations is a continual problem of education. Note our “fiche technique” explaining these for both sorghum and millet. We give these out to farmers (farmers like the pictures but generally don’t recommendations read French)³ in our on- farm training programs and we discuss the agronomic and marketing aspects with the farmers. Suffice it to say that we expect to avoid the downy mildew problem this year through increased pressure in getting the farmers to use the Apron seed treatment.

4. Dirty grain: the need for clean grain for use by food processors

Farmers are getting better at using the bache and also screens (Segou). But there are still problems. Beating the grain with “batons” on the “bache” or running over it with tractors destroys the “bache.” The appropriate long term solution is mechanical threshers. But the small machines tend to break down easily especially under the joint ownership of the farmers’ associations. We need bigger machines doing custom work as in Senegal. How to finance and organize this for the various zones of production now that the area in the new technologies is expanding rapidly is a question we need to address in 2012.

5. Repairs on mechanical threshers

³ Our principal effort of extension is getting a large enough number of farmers in each village using a practice so that the farmers will learn from each other.

In Tingoni, Sasakawa (our collaborator in the Segou region) introduced mechanical threshers during the last four years, three of which we collaborated closely with them.⁴ Our observations over these three years is that the threshers are not dependable due to frequent breakdowns. The problem with the breakdown of the threshers was the lack of ownership of the machine and thus poor maintenance and poor threshing methods. People in the village just used it until it broke down. The millet from the Segou region is known to have the highest impurity level (sand, stones and physical impurities). The millet heads are spread on the ground and a tractor is used to run on the pile to do the threshing. When millet is threshed on the ground, dirt, pebbles and other debris end up in the machine and it breaks down. However in the Mopti region the millet grain is clean because the threshing is done in large mortars by women. But when dealing with large quantities, the threshing becomes very painful. The woman cannot thresh more than 100 kg of grain all day long. Thus threshers are needed.

The solution to the threshing problem? Individual (private) owners that can make a profit by providing commercial threshing services. Private owners need to be able to make simple repairs and make sure that the millet is not dirty. This would be a better ownership method than Sasakawa's procedure of just simply making the equipment available to the village without proper management. In Senegal for example, there are larger and more dependable machines that individuals travel around with and do commercial threshing services. Breakdowns there are not a major problem. In Kaolack region, the largest millet growing zone in Senegal, we met a private person who uses a big thresher (1 ton of grain per hour) to do services after harvest in the different villages, from December to February of each year.

Therefore millet threshers exist and work. Farmers in the greater region of Segou or Mopti could use the same strategy. With established ownership rights in Mali the owner would charge for services, check for the quality of the cereal being introduced into the thresher and would know how to do repairs. They might also be able to do this with the smaller machines made locally in Mali.

6. Mechanical issues with the mechanized food processing units

Mechanical issues are always a potential problem with mechanized processing units and we do have problems in this area, though they are manageable and can be dealt with. We are striving to make successful examples with the Sotuba Incubation Center and are already working with two Bamako area entrepreneurs in this regard. Our goal is to have this be a model for processing technology transfer and for it to be sustaining after the finish of the project through other partners, training fees, and entrepreneur fees.

7. What is the progress in increasing grain yields over time?

Each year in the spring or summer after the previous crop year (at this time because we need to wait for the farmers and associations to sell later after the price recovery) we interview farmers and get yields, prices received, incomes as well as estimates of yields of the farmers not in the program and prices received by these farmers. We have these bulletins for 2005, 2006, 2007, 2008, and 2010 is in draft form being revised now as and we have added the regressions to this one.⁵ The progress in increasing grain yields is given' in these reports and they also show the profitability to farmers of these activities. Each year rainfall and other conditions are different so the best way to analyze this data is to take into account the climatic and other factors and to compare yields, prices and incomes with those not participating in the program. The between year comparisons suffer from the differences in climatic and other stochastic and economic factors. Yield comparisons over time do not mean much if one year was flooded (very adverse effect on

⁴ We left Tingoni after getting 150 ha and a well functioning farmers' association able to arrange its own inputs including credit, do storage and sell its millet and following well our agronomic recommendations. This is our policy to graduate these farmers associations and move on. We stay in touch and try to provide technical help if we can. Sasakawa repaired their storage facilities.

⁵ In 2009 I (Sanders) missed two months in the summer with an eye problem and we were running around trying to maintain our program and help IICEM do a big scaling up as requested by USAID-Mali.

sorghum and very good effect on millet- as in 2010) and another year was very dry at a critical period (let's see what happens to millet with the late rains in 2011 and note that on the heavier soils with sorghum we are in good shape). But the best way to evaluate profitability and sustainability is to talk to our farmers associations.

8. Drought damage in *décrué* sorghum

After the river or lake water recedes drought is a common problem in the *décrué* culture in Kayes Region. Solutions are:

1. The planting of drought tolerant genotypes such as Saba Soto and Saba Tienda which have extensive root systems as based on our studies and yield well in Mali under drought conditions. We will multiply seed of these two varieties for transfer of technology demonstrations.
2. Planting against the slope to prevent soil erosion and thus conserve moisture.
3. Use of tied ridges as has been shown by Sander's project to be effective in preventing rain run-off. The ridges will be constructed before planting and after the lake or river water recedes and will be used to catch the limited rainfall which occurs prior to the dry season.

9. Selection of academic trainees

Our initial proposal strongly suggested that selected participants acquire the needed English language skills in Mali, and then the training program would include a 6-month intensive English language component to bring them to the needed English skill level (TOEFL requirement) for graduate school admission. The five identified candidates were not already proficient in English and the time and resources were not available for English training in Mali. So our challenge has been to adjust our program plan, budget and timeline to first get all participants to the required English skill level to succeed in Master's programs; and second to identify Master's programs that would fulfill their training needs. To date we have accomplished English skill development and admission to graduate programs for all five participants.

Solution:

1. In selecting trainees a more rigid screening process should be conducted and only those with adequate English skills should be accepted.
2. Selected trainees should take English classes in Bamako where it is much cheaper than in the U.S.
3. Only applicants who successfully pass the English training in Bamako should be nominated to U.S. universities.

10. No cost extension for training program

Now that all five of the academic trainees have been accepted into their respective graduate schools to pursue their Master's degrees, our challenge is to make sure they complete their degrees with the funding provided. This will be difficult since all five trainees will take longer than anticipated to complete their degree. We are in the process of extending their training periods in TraiNet to allow each the needed time to finish. We have ***informed the Mali Mission of the need to grant a no-cost extension*** to increase our timeline to allow all participants to complete their Master's programs by mid-2013. We still await a decision.

11. Management problems

The processing project has had some technical and management problems in their component 1 activities in the Mopti/Gao region, though these are currently all being addressed. One entrepreneur has not been fully engaged in learning the technical side of processing and, is being considered to be dropped from the project. If so, this equipment will be quickly transferred to another processor.

Management wise in the production-marketing project we have to insure that people take responsibility and make decisions when stochastic factors affecting agriculture come up. We have to engage more in training to have a rapid program expansion and we are only in 2011 getting the published materials systematically laying out the program (see the Production-Marketing fiches for sorghum and millet). We are beginning to see the way to bring the banks in

systematically for input financing. Given the lack of collateral and the many small farmers without personal contacts with the banks, bank reticence was expected

12. Fulfilling gender requirements in long term training

The USAID Mali Mission requested that 50% of the academic trainees be women. However only 20% (one woman) was selected due to pregnancies and a recent birth. Since the USAID Mission/Mali did not approve one candidate to bring her new born child we had to replace her with a male since no other women candidates were available.

13. Security problem in northern Mali

The travel ban for U.S. Pls to the Tombouctou area makes it difficult to manage the Décrue Sorghum project.

14. Weak human capacity of collaborators

There is a need to train the DRA, NGOs and farmers who collaborate in the décrue project

15. Goat and poultry industry

There is a great potential for the use of sorghum and millet grain for the use as feed for poultry and grain and stover (forage) for the goat industry in Kayes region. Breeders should identify suitable genotypes for these purposes. We also need to test some of the highly digestible *bmr* (brown midrib varieties) developed by the CENTA program in El Salvador and now being evaluated in Central America and Haiti. These varieties are expected to increase milk production by 20%.

16. Seed production system

The lack of an effective and efficient seed production system has hampered our projects. Poor germination and varietal mixtures are often a constraint greatly limiting yields in our demonstration plots. In order to implement a wide diffusion of Saba Tienda and Saba Sôtô for the décrue system, seed production of the former and seed purification of the latter are needed. These are constraints that have to be resolved by IER and the national program.

17. Bank involvement

A remaining constraint for the Production-Marketing Pilot Project is to develop a strategy to increase local bank involvement in input finance at the start of the crop season so that input financing now provided by INTSORMIL can be transferred to local banks for sustainability of the project.

18. Pest problems in storage facilities

To minimize insect damage to grain in storage we need to substantially increase the use of PICs sacks and improve the management of grains in storage.

19. Feed production

The use of sorghum grain in the Kayes décrue system could be one way to link sorghum grain production to poultry production and the use of improved sorghum stover used for goat feeding. Sorghum breeders need to be encouraged to develop new genotypes suitable for the use of grain for human food, poultry feeding and the use of stover for goat milk production for the Kayes Region.

20. Seed quality

For millet our most important problem is clean seed. The canvas ("bache") we obtain for the farmers' associations to put on the ground are often torn up especially by running machinery over them to thresh. So we need to identify good threshing machines and work out a system to help the farmers' association either purchase them from their profits or

obtain bank loans to purchase them. Management and maintenance of these machines is also very important. This should probably be done privately rather than as a group function.

21. Markets for sorghum

For sorghum our most important problem is new markets. We have identified the priority of selling to the intensive chicken producers. Now we need to identify which firms have the requisite mixers to do that and when the relative prices (maize-sorghum) are favorable provide the information or incentives for this substitution.

22. Farmer training

We have bulletins for sorghum and millet which provide cookbooks for the necessary components of the program. However, these are for governmental agencies and the trainers. Who will do the training and what additional supporting materials do they need? The agronomy is simpler as the instructions are laid out in detail in our "fiche technique." However, the business management concepts to develop the farmers' association leadership and their members' ability to control them to work for the common good still need to be identified and incorporated into the fiche technique or into a module.

11. Success Stories (see Annex (jpeg) and attached MSWord files)

➤ *High prices for Quality Grain*

In the past two years, 2010 and 2011, the yield gains and price increases for millet in both the Segou and Mopti regions have been impressive. Yield gains with millet are difficult as millet is grown on poor soils and does not get as much attention as many other crops. In Segou we were getting 1.7 to 2 tons of millet per ha which is outstanding for the 2010 year. Further north in Mopti 1.3 to 1.5 tons/ha are still very good yields especially compared with traditional millet yields of 400 kg/ha or less. We expect similar yield results for 2011 if the late rains were sufficient. For prices in both regions farmers' associations that booked early systematically obtained high prices. P4P (a Gates supported NGO distributing cereals) paid over 140 CFA/ kg and food processor Mde Deme paid 126 CFA/kg, both in the Segou regions where prices at harvest ranged from 100 to 110 CFA/ kg in 2010. In Oualo, in the Mopti region, farmers in the "sodure" season were getting over 150 CFA/kg for their millet. Some of the villages waited too long and then there was apparently collusion between a local and the buyer with consequent very low prices. This is a management failure of the farmers' association and we are working on educating the membership to avoid this. Our initial focus is always on the agronomy cookbook and then we get into marketing and business management for the farmers' association. But we need to focus early on the marketing and the price search.

➤ *Malian Thick Sorghum and Millet Porridges Decrease Hunger (See below)*

➤ *High Yields for Mali Sorghum and Millet Farmers (see below)*

➤ *Millet Technologies Increase Food Security and Farmers' Incomes (see below)*

➤ *Rooting Depth and Architecture are Critical for Productivity of Décrue Sorghum (see below)*

12. Lessons learned

Varietal selection by farmers

Using Grinkan as with any Caudatum can give much higher yields but it also increases susceptibility to late rains. These late rains lead to mold and increased insect attacks. Both lead to lower yields and poor next year germination. So we need to instruct farmers to avoid early planting. However, late rains are still going to be a problem from time to time as they are in the US or anywhere else getting high sorghum yields. So farmers should be informed and from time to time new seed production activities will be necessary as in 2011 in Koutiala. Given the potential of Grinkan to double to triple local yields with excellent following of recommendations farmers are expected to continue to show substantial interest in Grinkan and her progeny, which are being released now.

Poultry producer demand

Just informing intensive poultry producers about the potential for sorghum to substitute in the ration for maize. We need to target mixers and intensive producers with the requisite equipment for mixing when the prices are favorable for sorghum relative to maize and push more proactively to overcome the inertia in staying with a maize based ration. Sorghum has been used in the ration when prices were favorable and by one mixer-producer for some time. The problem in Senegal was not being able to get enough sorghum when the prices were favorable. We need to be more proactive in developing this market.

Soil fertility recommendations

In the last two decades when Mali needed to be investing in soil labs, doing soil testing and producing soil specific recommendations for farmers, the low fertilizer input philosophy dominated. Now we still need soil and region specific recommendations for our farm level work. For example, the response of *décrué* sorghum to fertilizer depended upon the soil type and location. In poor soils such as those in Tonka, the sorghum crop responds to nutrients. Maximum decreases in grain yield were observed when N or P were deficient. In some locations no response was observed. Thus, a future INTSORMIL program activity needs to include the modernization and acceleration of the soil testing activity in Mali. Testing and recommendations need to be provided at a low price to farmers. Publishing of the soil testing results should be done so that the empirical basis for soil specific soil fertility recommendations at a farm level can be developed. We intend to get input from American soil scientists and start on this activity in the summer of 2012.

Plant population

Increasing plant population (minimizing spacing) in *décrué* sorghum increased grain yield across all genotypes, suggesting better resource use (light, nutrients and water).

Seed and soil treatment with pesticides

Use of seed or soil treatment with pesticides in *décrué* sorghum increased the number of plants that survived till maturity. However, there were no clear differences for number of panicles infested with pests. Further research is necessary on use of other chemicals, rates and methods of application.

Cultivar evaluation

The demonstration plots showed superior adaptability of varieties Saba Soto and Saba Tienda when compared to Niaticama in the *décrué* production systems in northern regions of Mali. The reason for their performance was evident in the rooting depth study conducted at Kansas State University (see success story below). However, there is still a need to test more genotypes for yield stability and grain quality in this region. As a result we planted additional demonstration plots with new cultivars; Saba Sôtô Koreye, Saba Al Bakar, Saba Sôtô Kara in Goundam.

Soil water dynamics in the décrue system

There is a need to better understand the water dynamics in the topographic soil profile of the décrue system during the growing season of sorghum, particularly during its reproductive growth stage. This is especially important for designing water harvesting and other water conservation strategies. We will purchase appropriate equipment to monitor water in the soil profile in 2012.

13. Annexes



SUCCESS STORY

Malian Thick Sorghum and Millet Porridges Decrease Hunger



Photo by B. Hamaker

Very thick sorghum and millet porridge delays the feeling of hunger

Maliens often experience hunger at the end of the dry season when most of the sorghum and millet grain from the previous crop has already been consumed. A study was recently conducted by the INTSORMIL/IER Project to examine thick sorghum/millet porridge consumption related to preference and satiation (lack of a hungry feeling) in the Sikasso, Segou and Mopti regions of Mali. This was part of a larger study to understand the effect of thick porridges, and delayed glucose delivery to the body, on satiety and overall food consumption. The satiety study was designed so that participants consumed as much tô as they wanted until they felt “full”.

Participants were asked at 2 and 4 hours after consumption to judge their feeling of hunger (0=full, 1=slightly hungry, 2=hungry, 3=very hungry). Very thick tô, thick tô, medium tô and thin rice porridge were compared.

The thick porridges were very satiating (hunger satisfying). Satiety study participants revealed large differences in their feeling of hunger 2 and 4 hours after consumption of the porridges of different thicknesses. Notably, participants still felt full 2 hours after eating very thick and thick tô, and after 4 hours only felt slightly hungry. After consuming the control rice porridge, at 4 hours participants felt very hungry.

Villagers eat thicker tô than city dwellers, perhaps related to its satiating effect and extended energy property. Urban populations should be encouraged to consume more sorghum/millet tô by conducting a nationwide publicity campaign with the slogan “*eat sorghum and millet – they are healthy satiating foods (not ‘poor’ foods)*”. This is particularly important at this time of high prices for grain imports. If one million families ate only one more meal of sorghum/millet tô each week (using about 1 kg of flour for the meal), this amounts to about 50,000 metric tonnes of grain a year, which is more than the total wheat imports into Mali in 2008.



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SUCCESS STORY

High Yields for Mali Sorghum and Millet Farmers



Photo by E. A. "Shorr" Heinrichs

Millet farmer of the Cooperative Yereta-Ton, Tingoni, Mali who follows INTSORMIL/IER recommendations and a food processor who purchases his millet grain.

In response to the President's Global Food Security Initiative INTSORMIL is conducting collaborative research with Malian partners to improve farm income and human and animal nutrition by overcoming constraints to sorghum and millet production, marketing and utilization. To increase sorghum and millet production in Mali, improved technologies must be introduced to farmers and new marketing strategies must be developed so as to avoid price collapses at harvest time. To promote this concept INTSORMIL conducts on-farm demonstrations of existing technology in collaboration with the Institut d'Economie Rurale du Mali (IER) and several NGOs. Improved seed, inorganic fertilizer and improved agronomic practices such as water conservation are being introduced in farmers' fields at the village level in Mali. Farmers following INTSORMIL recommendations consistently double yields with the best farmers obtaining 2 tons of grain/ha. Traditional yields are less than a ton. As productivity of sorghum and millet is increased, the demands of the rapidly expanded markets for processed foods and for poultry feed become a central concern. According to the eminent food scientist, Prof. Lloyd Rooney of Texas A&M University, "a consistent, high quality grain supply is the first prerequisite for the development of a sorghum/millet-based food processing industry in Mali. The INTSORMIL directed Production-Marketing and Food Processing projects funded by USAID/Mali are focusing on the consistent supply of high quality and clean grains for use by both the food processing industry and the poultry industry. To promote the use of millet as a human food INTSORMIL promotes connections between farmers' groups and the rapidly growing sector of millet food processors of couscous, arraw, sanakal, tchakri and yogurt in Mali. For sorghum the principal source of rapid demand expansion is likely to be as a feed base for intensive poultry production. Because of the high price of imported maize and the higher risk of aflatoxin from maize Malian feed mixers and poultry producers are searching for locally grown sorghum as an alternative. Sorghum has less mycotoxin problems and can be cost competitive as a substitute for maize in poultry feed. However, there is often insufficient sorghum available for the poultry industry, a problem the INTSORMIL/IER project is solving by transferring technology to Malian farmers that increases the quantity and quality of sorghum produced. The increased production of both millet and sorghum increases farmer incomes, reduces poverty and promotes both the human food processing industry and the poultry industry in Mali. INTSORMIL has generated powerful impacts at the village level and is now working toward the next step of rolling these impacts out on national scales. For scaling up of the Tingoni model, IER and INTSORMIL were involved as technical consultants.



SUCCESS STORY

Millet Technologies Increase Food Security and Farmers' Incomes



Photo by Ouedembe Botorou

The head of the millet farmers' association in Tingoni. The new millet cultivar "Toroniou" introduced under the IER-INTSORMIL project, sponsored by USAID, has helped the 100 members of the association to improve their production, to become more food secure and to increase their revenues.

"Before 2006, we were not self-sufficient in millet because the yields were very poor. But thanks to the introduction of the "Toroniou" cultivar from the INTSORMIL project farmers are becoming more skilled in millet production. Now many farmers in this village are able to meet their home consumption in millet and make more money." Siriki Diarra, president of the cooperative "Yeretaton" for millet production in Tingoni, expressed his appreciation for involvement in the IER-INTSORMIL project financed by USAID-Mali.

Millet is the main crop grown and consumed in the village of Tingoni. However, average yields of the local variety were usually low, no more than 0.8 to one ton/ha in good years. Farmers can barely meet their family home consumption. Continuing soil depletion and the lack of access to credit for fertilizer resulted in low millet yields. Since 2006, the Production-Marketing component of the IER-INTSORMIL project has introduced a millet cultivar "Toroniou" and has trained Tingoni farmers in the use of improved agricultural techniques and marketing strategies to increase millet productivity, prices, incomes, and food security.

In 2009, a year after their graduation from the project, farmers' yields for the improved cultivar were still high. Yields average 1.5 tons/ha and reach 2.3 tons per hectare for the best farmers. These yield achievements have no precedent in the village. Farmers used the increased income from millet to satisfy their household consumption requirements, meet family expenses and buy clothing and other gifts for women and children.

Moreover, producers in the association earned more income by following the marketing strategies. Bargaining power has increased and strong marketing ties established with food processors and other institutions. In 2009, the cooperative sold 35 metric tons of millet at a price premium of \$0.31/kg to the World Food Program (WFP) and Mme Deme, a millet food processor. At that time the millet price was \$0.26/kg in the local market. Thus, a net gain of \$1,750 was earned by the cooperative from the price premium. This gain was shared with members and the farmers association continued to use their rotating fund for fertilizer purchases in 2010. Also, in 2010 eight new farmers' producer associations with 50 to 200 members planted 500 ha under the new technologies. USAID/Mali funded project IICEM and Global 2000 coordinated the development and implementation of this scaling up of the Tingoni model. IER and INTSORMIL were involved as technical consultants.

RESEARCH BRIEF

Rooting Depth and Architecture are Critical for Productivity of Décrue Sorghum



Receding lake water in northern Mali.



Mr. Wahab Toure, IER Agronomist interacting with extension agents and décrue farmers in northern Mali.



Most of the sorghum in Mali is grown under rainfed conditions on the plains, but some is grown in the banks of rivers and lakes when the water level recedes (sorgho de décrue or décrue sorghum). This is one of the oldest and most fascinating methods of cultivating sorghum. The décrue production system is particularly practiced around water bodies in the Mopti, Gao, Tombouctou and Kayes regions. This production system plays an important role in the food security of these regions. As the floodwater recedes, seeds are sown in muddy soil and the crop is grown on the stored soil moisture. Depending upon the season, water from lakes and rivers spreads and recedes slowly. The décrue system is vulnerable to changes in the amount of water and the dry period following the recession of water. Thus, there is a large variability in amount and depth of soil water. This presents a unique challenge for selection of appropriate sorghum genotypes that can extract water from the deep profile and use soil water more efficiently. Not all genotypes are productive in décrue systems. Little is known about genotypic performance under these production systems. For improving yield of décrue sorghum, it is important to identify traits that contribute to greater yield stability in the extended dry season.

Thus, a research project funded through the USAID Mali Mission was initiated with a team of researchers led by Mr. Abdoul Wahab Toure from IER and Dr. Vara Prasad from Kansas State University (KSU) to collect and test the performance of local and improved sorghum genotypes under décrue production systems in northern Mali. It was observed that certain local genotypes (e.g. Saba soto and Saba tienda) had more stable yield in both good and dry years. The improved genotype Niaticama performed on par with local genotypes in a good year, but failed in a dry year. This was a very intriguing observation so we continued research to identify the reasons for this response.

Mr. Wahab Toure visited KSU and worked with Dr. Vara Prasad to understand the growth of décrue genotypes. Our aim was to identify traits unique for décrue sorghum. Research was conducted in controlled environment facilities. Four sorghum genotypes (two genotypes Saba soto and Saba tienda from the décrue region, one improved genotype Niaticama from the plains) were exposed to two moisture treatments: fully irrigated (no stress), and drought stress. Above and below ground growth was quantified.

Results from this research indicated that local genotypes Saba soto and Saba tienda had deeper rooting systems under both normal and drought conditions, when compared to Niaticama. In addition, Saba soto and Saba tienda had more number of fine roots distributed across the entire rooting depth. These traits could help extract water from deeper and wider soil profile and help produce high biomass and yield in the dry season. Research is currently underway to evaluate more genotypes and build a breeding program to develop suitable genotypes for the décrue production system.

For more details contact: Mr. Abdoul Wahab Toure (e-mail: abdoulwahab.toure@yahoo.fr) or Dr. Vara Prasad (e-mail: vara@ksu.edu).



Mr. Toure at experimental set up at Kansas State University. Photos (R) shows profuse rooting of local genotypes Saba tienda and Saba soto compared to Niaticama.



Niaticama Saba tienda Saba soto

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