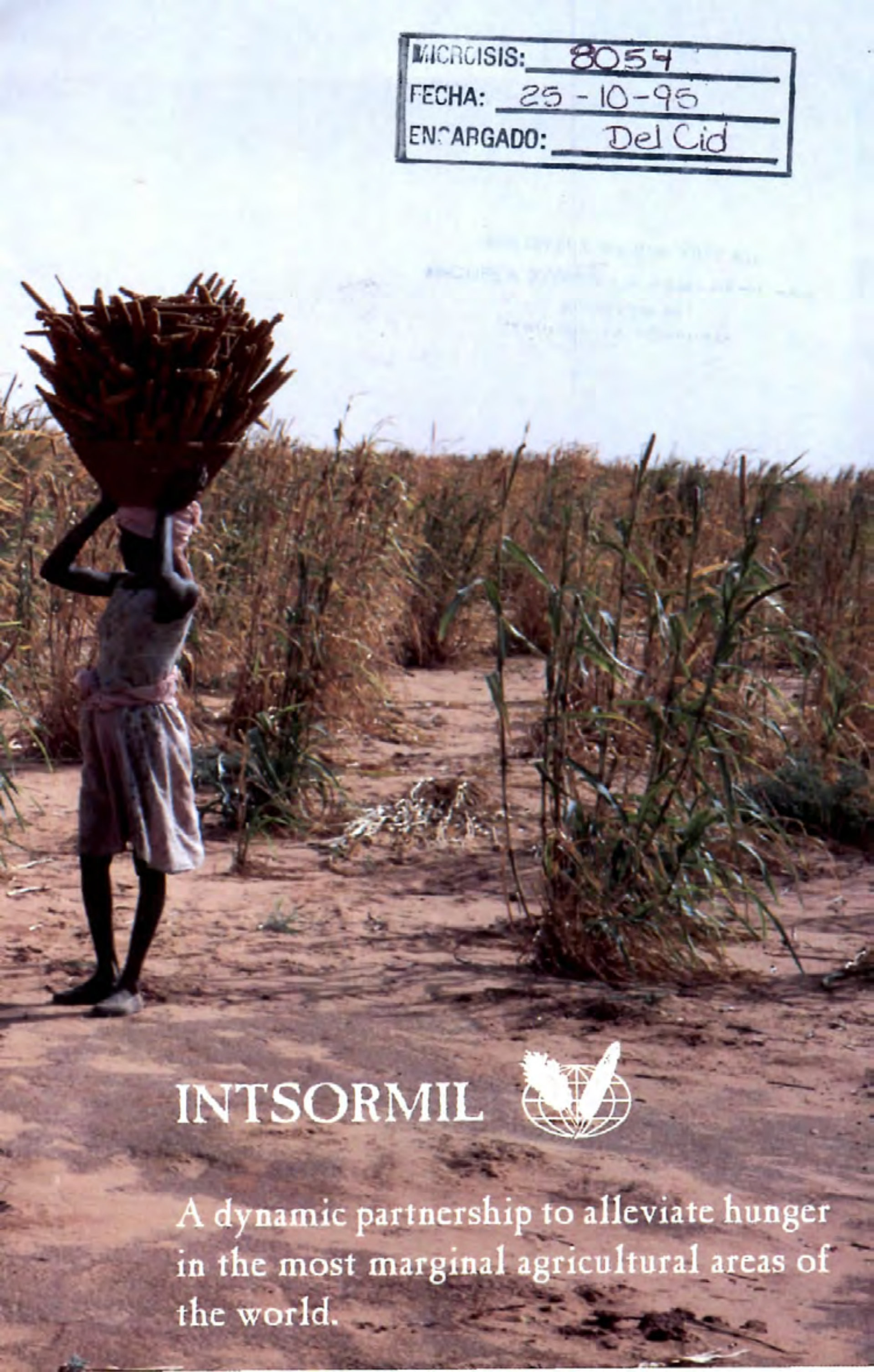


INTSORMIL

A dynamic partnership to alleviate hunger in the most marginal agricultural areas of the world.

INTSORMIL:
Milestones for the 1990s

In the driest regions of Africa and on the marginal hillsides of Central America, farmers cultivate sorghum or pearl millet as their crop of last resort.

In mountainous Honduras, *sorghum is planted as hunger insurance*, delivering enough grain even in the worst years to supplement the meager supply of maize for tortillas and tamal. Across the Atlantic in Burkina Faso, where the per capita income is less than $350—*one of the poorest countries in the world*—women cultivate red sorghum on the impoverished plots of their family farms to brew into a beer that releases otherwise inaccessible nutrients. Women in Niger, Burkina's neighbor to the east, spend many hours every day pounding pearl millet with wooden mortar and pestle into meal to feed their families.

Sorghum and pearl millet help keep hunger at bay in the poorest countries of the world.

Since 1979, American and host-country scientists working in Central America, South America and Africa have contributed their expertise to the International Sorghum and Millet Collaborative Research Support Program, known around the world as INTSORMIL, to enhance the natural advantages of sorghum and millet to feed and finance many of the world's poor.

INTSORMIL has focused the attention of international researchers on improving the cultivation and processing of these two stubborn grains that continue to yield a crop in even the most daunting conditions.

And they are making headway...in Botswana, Burkina Faso, Colombia, Honduras, Kenya, Mali, Niger, Senegal, Sudan and, yes, back home in the U.S. as well. We tell their stories here.

INTSORMIL, funded by the U.S. Agency for International Development, and supported by developing country institutions:

- researches sustainable agricultural methods that can help improve the quality of life in countries where sorghum and pearl millet are the principal food crops,
- strives to enhance the nutritional value, processing quality and marketability of these crops,
- looks closely at household-level decisions that influence the implementation of new technologies,
- works with local scientists and farmers to develop efficient means of production that protect the fragile environment,
- collects and utilizes valuable germplasm from around the world,
- continues to develop new varieties that have better resistance to disease, insects and drought.

INTSORMIL is developing new strains of sorghum and millet that can be cultivated using traditional farming methods with moderate increases in inputs, and processed and marketed according to the tastes of the local community.

The INTSORMIL story—an itinerary for progress:

INTSORMIL is a farsighted program of the U.S. Agency for International Development.

INTSORMIL works to improve the quality and return of sorghum and millet in developing countries that rely on these crops as food staples, helping them to better feed themselves. In 1979, existing breeding programs from four Land Grant universities were merged to provide a collaborative base for efforts to improve food quality, insect and disease resistance and stress physiology for both sorghum and millet. Project components integrated socioeconomic considerations, product utilization and marketing, cropping systems research and pest management into the research program.

The first External Evaluation Panel reported:
"never before have the research capabilities and the concern for the peoples of the developing world, by staff and scientists of the U.S. agricultural universities, been so effectively organized into a cooperative activity bringing professional and technical knowledge to bear on the problems of ordinary sorghum and millet growers."

The challenges facing ordinary sorghum and millet growers are still the focus of INTSORMIL's research agenda.

In conjunction with seven other Collaborative Research Programs (CRSPs) funded by USAID, INTSORMIL works to alleviate hunger and poverty in developing countries through crop improvement, coordinated research, and sustainable management of agriculture and natural resources. The collaborative nature of the CRSP network ensures a mutual commitment by both U.S. and developing country institutions and provides a conduit for reverse technology flow into U.S. universities.

INTSORMIL works in dynamic partnership with the National Agricultural Research System (NARS), host country governments and institutions, international research agencies like ICRISAT, ICARDA, CIMMYT, MIAC, CIAT and researchers around the globe.

Collaboration is INTSORMIL's key to success. By working as a catalyst, INTSORMIL helps scientists in developing countries to take responsibility for solving their own problems.

Through collaboration with other international and regional agencies, they are making small breakthroughs that could affect the lives of millions.

INTSORMIL's collaborative approach to development is cost effective, providing continuity and stability to struggling agricultural research institutions through long-term commitment.

Five ecogeographical zones have been selected for this work. Each zone has a prime site where unique constraints are addressed. The INTSORMIL network of collaborative scientists is then used to transfer research results and new technologies to neighboring countries in the region. The five ecogeographical zones are: West Africa, East Africa, Southern Africa, Mesoamerica (Central America) and South America.

And yet, in many parts of the world the farmers who will influence the progress of agriculture are geographically and socially isolated from researchers. **The most isolated farmers in the developing world are often women, who provide a majority of the agricultural labor and play a decisive role in allocating family resources. INTSORMIL addresses these farmers, too.**

Women producers play significant role in resource allocation:

INTSORMIL economists at Purdue University analyzed data from Burkina Faso that enhanced their understanding of womer roles in resource allocation. They are now working to uncover th most productive methods to improve the economic status of families.

• Rural Burkina women marry int extended households that include a husband, up to three other wives an their offspring.

• The constraints on these women numerous. They work more hours ea day than men or urban women. Hal a 12- to 16-hour workday is spent preparing food, collecting firewood a water, and caring for children.

• The other half of their workday i divided between communal and private agricultural plots or income generating activity in the marketplace. Labor on the communal plots must be completed before women can work on private fields.

• Communal plots are usually the most productive lands whe application of new technologies brings the best return.

• By contrast, on the less fertile private plots, women's lack of income for purchased inputs like fertilizers (crucial to expandec yields) results in very low returns.

Microeconomic analysis of household income in the Solenzo region of Burkina Faso has led INTSORMIL economists to conclude that women benefit as the household economy improves a as they shift their labor from their private family plots to comm nal lands.

Field data from Burkina Faso, Gambia and Cameroon indicate that omen maintain a firm negotiating stance in the household. In fact, hen crops are profitable, women are compensated for the increas-g amount of time they devote to male-dominated communal plots at are the focus of technological interventions in that region.

The researchers submit that women egotiate their "wages" in a coopera-ve model of bargaining. They receive ayment, including food allocations d gifts, in exchange for meeting the bor demands of the household head. they are not compensated adequately d in proportion to the time spent in mmunal fields, conflict ensues, and omen withhold their labor in subse-ent years.

Microeconomic modeling of annual farm income in the Solenzo gion was revealing. Modeling results showed:

- Income increased by 69 percent (from $922 to $1,556 per year) with the introduction of new technologies solely on communal fields.
- Women shared in the increase, doubling their income.
- Gains from applying new farming techniques exclusively to the private fields were less significant, household income and women's income dropped.
- Introduction of technology on both private and communal fields increased a woman's personal earnings significantly, but total household earnings deteriorated nearly 10 percent.

Directing development assistance efforts specifically to im-oved productivity of women's plots was shown to augment the come of the individual women but at a detriment to the total m income.

In areas where new crop production practices are successful, another important route to improving the welfare of women is to enhance the efficiency of non-farm activities like food processing and preparation. Time savings in housework could liberate time for work on private plots, income-generating off-farm labor, or for leisure.

INTSORMIL researchers are now exploring the potential economic impacts of reducing firewood requirements, minimizing the distance to water sources, improving food processing and preparation efficiency.

One of the most promising means for helping women and men to generate income in West Africa is the marketing of new food products. INTSORMIL Food Scientists at Texas A&M University adapted centuries-old rice processing techniques to sorghum and millet to create Sori and Milri. A variety of traditional foods can be made from these two preparations. **Sori and Milri are products designed explicitly for the marketplace, using technology available to any traditional farmer.**

- Few ready-to-cook, shelf-stable products made from sorghum and millet were available in West Africa, while processed rice has been available since colonization.
- Rapid urbanization has created an increasing demand for convenient food products.
- Most of the rice consumed in West Africa is imported.
- Sorghum and millet are grown widely, even in the most marginal areas.

Sori and Milri have many advantages. Processing adds value, convenience and storage life. **Economists estimate that it could reduce time women spend in food processing by 20 percent.**

Ensuring marketability via local research input and product testing:

"If the grain cannot be processed and consumed for food, then the agronomic and breeding research has been wasted," Lloyd Rooney, INTSORMIL Food Scientist, Texas A&M University.

Sori and Milri are processed through a simple parboiling (soak, boil and air dry) technique, which transfers to sorghum and millet the convenience of rice without giving up nutritional value. The technique was introduced in the laboratory, but its development took place in the villages and towns of Mali where women were asked to test both the cooking process and the final product.

As women tested Sori, several remembered their grandmothers processing sorghum in a similar fashion. **The credit for developing a consistent, marketable product goes to local women, especially to Mme. Miriam Haidara, a Malian food scientist who coordinates Sori research in Bamako.**

In nearly five years of testing, scientists listened carefully to input from consumers, restaurateurs and housewives. They streamlined the cooking process to reduce energy consumption, tested several varieties of sorghum, and discovered that air drying not only saved energy but resulted in a superior product.

Parboiling:

- improves the food yield of sorghum by decreasing losses during milling,
- reduces toxic tannins,
- facilitates removal of the seed coat,
- minimizes a mousy smell that discourages many from keeping processed pearl millet.

Market approach enhances success of new crop varieties:

The major hurdle to marketing success is the lack of consistent food quality in improved sorghums. Native African sorghums have good food quality but are difficult to process, requiring time-consuming pounding with a mortar and pestle. U.S. sorghums are high yielding but poor in food quality. While most of the sorghum grown in Africa is consumed as food, variety improvement programs have given priority to yield rather than food quality.

INTSORMIL recently revised research priorities based on market demand. The Food Quality and Utilization Project delineated characteristics crucial to food preparation and processing that preserve local standards for taste, aroma, color and texture. Breeding programs now incorporate acceptable attributes for traditional and industrial use early in crop improvement.

Grain color is especially important during processing; brown or red grain is less desirable in the marketplace. Several new varieties recently distributed by INTSORMIL offer enhanced food quality through tan plant color and white translucent grain. These strains show excellent capacity for hybrid combinations that offer drought tolerance and disease resistance.

The evolution of food quality hybrids illustrates the necessity of international cooperation in agriculture. The breeding stock for one INTSORMIL parent line, ATxARG-1, originated in India, then was selected by an Argentinean scientist from a germplasm observation nursery in Manfredi, Argentina. The Argentines had obtained the seed from ICRISAT (the International Crops Research Institute for Semi-Arid Tropics). Eventually, it was brought to Texas by an INTSORMIL researcher. ATxARG-1's progeny was selected to be adaptable to a wide array of environments in Latin America, Asia and Africa, as well as the United States.

Tapping worldwide genetic diversity is increasingly important to maintain productivity and stability for sorghum growers. Through INTSORMIL cooperation, exotic sorghums from Argentina, China, Ethiopia, India, Sudan, Zimbabwe and many other countries were introduced at the USDA winter nursery in Puerto Rico. After being evaluated by INTSORMIL plant breeders for potential crosses with U.S. elite varieties, these introductions are maintained for redistribution into the international sorghum improvement network.

While much of the sorghum grown in the United States is red sorghum used for feed, white or tan food-quality sorghums are in demand throughout the rest of the world. **The production of light-colored sorghums developed by INTSORMIL could enhance export opportunities for U.S. farmers.**

The introduction of improved varieties in Africa has met with an almost insurmountable obstacle, a tiny winged insect called a headbug, that damages all but the unimproved native sorghums, leaving them vulnerable to molds, difficult to store and unable to process. Local sorghums show little damage but are low yielding and the resistance trait is not transferable.

Overcoming biological constraints through cooperative research:

Headbugs, tiny invaders that feed on the developing sorghum grain, have blocked the introduction of higher-yielding, food-quality cultivars in West Africa. Headbugs pierce the sorghum kernel, sucking away the juices and often laying eggs in the outer endosperm layer.

• A microscopic headbug "bite" can leave behind devastation.

• In susceptible strains, headbug damage changes the grain, leaving behind a shriveled mass, worthless for food use.

• Headbugs, grain molds and weathering work together to diminish harvests and deteriorate the quality of stored grain.

• Since little grain is sold until the weeding of the next crop, storage quality is crucial to expanding income.

• Insecticide-based pest control schemes are too costly to be considered in most of Africa.

"Headbugs are preventing us from making any improvement that benefits the farmer," said George Teetes, who directs the insect management strategies for INTSORMIL from the entomology department at Texas A&M. "It's more than an obstacle, it's a complete deterrent to being able to improve sorghum cultivars in that area of West Africa."

But Teetes is optimistic.

• INTSORMIL plant breeders, entomologists and food scientists have cooperated to develop new methods to screen for resistance and evaluate crop damage.

• Researchers have discovered a direct relationship between headbug resistance and resistance to mold damage.

• Innovations like these will speed the progress toward new income-generating opportunities for native farmers.

INTSORMIL scientists and national scientists from Mali overcame a major barrier to progress with the identification of superior headbug resistance in Malisor 84-7, a line developed by ICRISAT/Mali. Malisor 84-7:

- combines kernel hardness, favorable seed color, processing ease and nutritional value,
- localizes damage to the area the insect pierces, rather than opening the entire kernel to molds and fungal damage.

Two more obstacles were overcome before Malisor 84-7's headbug resistance could be passed on to progeny. The trait is recessive and initial breeding efforts resulted in only a few resistant strains. In addition, the selection process required heavy infestation to make lasting conclusions.

INTSORMIL plant breeders refined their selection techniques and persisted in breeding efforts. In 1992, field testing showed reasons for optimism. Trials indicated that resistance had been successfully transferred to elite sorghum lines.

Breeders are now selecting progeny that can be readily used in traditional farming systems, combining improved food quality and productivity with characteristics that make Malisor 84-7's progeny an attractive option in the harsh environment of West Africa.

"In subsistence agriculture, stable performance under low-input production practices is more important than high yields," Lynn Gourley, INTSORMIL Plant Breeder, Mississippi State University.

INTSORMIL scientists at Mississippi State University are taking on a most daunting challenge to agricultural development assistance by working to improve sorghum production on acidic soils that are toxic to most plants. The high acid content liberates aluminum for uptake by plant roots, making crop production nearly impossible.

Acid soils dominate:

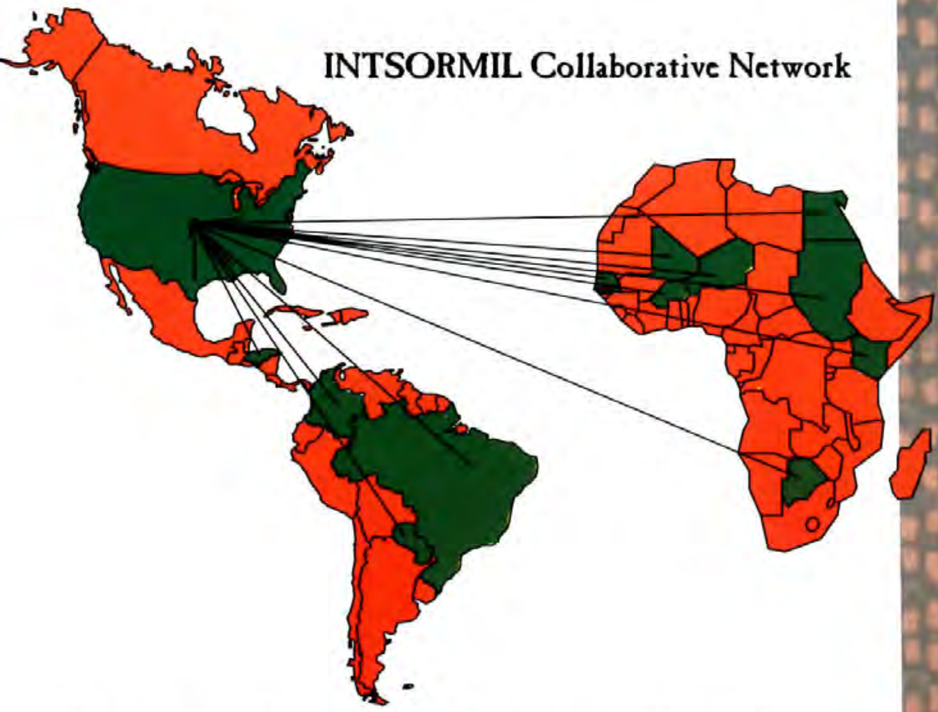
- a large portion of central Africa.
- the immense Llanos in South America, that cover parts of Colombia and Venezuela,
- the Cerrado of Brazil.

INTSORMIL selected the eastern plains of Colombia to screen for acid-tolerant varieties of sorghum. Soils there are so acidic (between 4 and 5 pH) that toxic aluminum is soluble and is absorbed by plant roots. At that low pH, the aluminum blocks the uptake of all other essential nutrients and is poisonous to roots and tissues, eventually killing the plant.

U.S. farmers modify even slightly acid soils to gain higher yields. In Africa and South America, farmers have little access to the expensive resources needed to neutralize acid. But now, due to collaboration between the Colombian Agricultural Research Institute (ICA) and INTSORMIL, two varieties of acid-tolerant sorghum have been released that promise productivity on lands saturated with aluminum. Sorghica Real 40 and

Sorghica Real 60, respectively, tolerate up to 40 and 60 percent aluminum saturation, allowing 200,000 hectares to enter into crop production in Colombia.

Acid-tolerant varieties can benefit U.S. agriculture as it shifts to lower input production strategies. Sorghum developed for infertile acid soils and marginal conditions in Kenya and Colombia have the advantage of versatility. These varieties perform in the most marginal conditions, yet improve performance and yield if fertilizer or irrigation is used.



The most critical research to the Sahel region of Africa addresses a problem that has been exacerbated by intensive land use. Today, with massive population growth and urbanization, traditional farming methods can no longer satisfy the demand for food. The shift to intensive monoculture to increase production has aggravated the spread of a parasitic weed that has enormous destructive force.

Linking sustainability with innovation:

Striga (S. hermonthica) is a parasitic weed that produces a distincti fuchsia-colored flower. Its impact is devastating throughout large areas of Africa. An African-based study estimates that ***Striga* causes the loss of up to 40 percent of potential sorghum and millet produ tion in Africa each year.**

Striga is also found in the United States in the border region of the Carolinas, where it is called witchweed. The infestation there originated from seeds imported from Africa or Asia. An Asian scientist, who had battled the parasitic weed in his own country, identified it the same weed that caused damage to crops there.

The USDA built a *Striga* research center in the 1950s, spending ov $60 million to bring the problem under control. A 15-20 county area was the testing site for an expensive arsenal of chemical and biologi weapons. Yet, none of these methods is feasible for Africa. And, aft 40 years of effort, three U.S. counties remain in quarantine.

A single *Striga* plant produces more than 50,000 seeds each season Since some seeds remain viable for up to 20 years, seed quantities in continuously cropped fields increase astronomically.

In traditional cropping systems, cereals were grown only intermittently on a plot of land. Before *Striga* began to interfere with produc tion, the farmer moved on to a new plot. The abandoned plot was le fallow for 10 to 20 years. *Striga* rarely produced the high seed and plant populations associated with monoculture.

***Striga* is so well-adapted to its harsh environment that scientists searched for weak links in the chain of events leading to yield los in sorghum and millet.** The weakest link occurs at germination whe a tiny *Striga* seedling survives for only a few days unless it can mak contact with a host sorghum root.

Stimulated by an intricate series of chemical signals, sorghum nourishes its rootless freeloader, activates development of *Striga's* shoots and leaves, then allows the parasite to take control, causing it own decline. Without these signals, *Striga* would continue to grow a mass of disorganized cells.

INTSORMIL researchers were the first to isolate a chemical called ***orgoleone*** **that is exuded in minute amounts by sorghum roots and timulates seed germination in the laboratory.** They hoped to open he gates to practical methods for controlling *Striga*. But numerous esearch trials have shown no correlation between sorgoleone and usceptibility of sorghum to this virulent weed.

The process of identifying sorgoleone did, however, lead the way to step-by-step breakthrough. INTSORMIL biochemists and plant reeders cooperated to:

- devise a way to disrupt the host-parasite interaction,
- design a new genetic screening technique that consistently predicted *Striga* resistance,
- replace time-consuming field trialswith a new laboratory assay that allows for much wider genetic screening,
- develop optimal cultivars that combine *Striga* resistance, drought tolerance, food quality and increased yield.

The best material was tested in fields cross the Sahel. These cultivars were rogeny of a sorghum genotype labelled SRN-39 that showed significant *Striga* esistance in the mid-1980s. In close collaboration with national breeding programs in Sudan, Niger and Mali, NTSORMIL breeders evaluated progeny of SRN-39 that combined esistance with superior agronomic characteristics and food quality.

- Thirty to 40 outstanding cultivars have been developed.

- SRN-39 has been commercially released in Sudan where it is ultivated on over 30,000 acres.

- INTSORMIL is working to expedite distribution of seed for ational research programs in Sudan, Mali, Niger and Kenya.

Farm-based research adds economic value to local varieties:

The benefits of field testing and farm-based research have been most visible in the mountains of Honduras where farmers seldom buy hybrid seed. They obtain seed through an informal network of neighbors who act as landrace custodians. The INTSORMIL program centered at the Escuela Agricola Panamericana near Tegucigalpa, targets these seed distributors for enhanced maicillo testing.

Maicillos are the landrace sorghums originally imported from Africa that have been planted for centuries in Central America. The long-stemmed sorghum is intercropped with maize, maturing after the maize has been harvested.

Rather than disrupting the existing networks, and allowing the ability to purchase hybrids to emerge as a limiting factor, the INTSORMIL farm-based maicillo testing program:

- acquainted local farmers with hybrids and identified local seed dealers,
- gave them an unbiased perspective to help in selecting hybrids for their individual needs,
- helped the fledgling seed companies to select hybrids adapted to Honduran conditions.

"The creation of enhanced maicillo cultivars and their subsequent deployment on-farm, not only is intended to increase genetic diversity *in situ*, but to stave off maicillo's replacement by introduced cultivars," said Dan Meckenstock, Honduras project leader.

Dionedes Paz, who lives along a gravel road near El Carreto, Honduras, collaborated in a population dynamics study of a pest (Langosta) that plagues landrace sorghums. His first harvest of the INTSORMIL-enhanced maicillo was used to make tortillas, to feed his livestock and to plant an additional hectare the following year. The early maturing grain enabled him to sell his next harvest while the market price was still high.

The enhanced maicillo performs better than commercial hybrids in the tropical conditions of Honduras due to a more efficient assimilation system. In fact, maicillo research has led to the discovery of shade tolerant varieties of sorghum that may be valuable to farmers in Mississippi and around the world. The success of this program provides a model for other countries without existing hybrid seed companies.

A second advantage of the program is the conservation of maicillo genetic material. INTSORMIL cooperated with an existing seed nursery and assisted the collaboration of national programs in Guatemala, El Salvador and Honduras. Maintaining genetic diversity will protect Honduran farmers from the risk of crop devastation from changing climatic conditions and disease. It also enriches the possibilities for sorghum improvement worldwide.

Worldwide progress ...

Sorghum and millet were designed by nature in the harsher regions of the globe to withstand drought, insects, and poor soil fertility.

INTSORMIL scientists are working with nature to enhance the productive capacity of these crops and to ensure that appropriate innovations find their way into farming practice and family nutrition.

• INTSORMIL and the Botswana Department of Agricultural Research developed and implemented a comprehensive nationwide research program for farm-based investigations to improve tillage and fertilizer practices for dryland sorghum.

• Investigators estimate that even at the early phases of introduction, new sorghum cultivars in Sudan and Honduras exhibit internal rates of return of 23 and 32 percent respectively. Averaged over a 30-year period the annual **return from research totals $983,000 for the Sudanese and $699,000 for the Honduran cultivars.**

• **Two new releases** (Sorghica REAL 40 and 60) made by the Cooperative Project ICA/CIAT/INTSORMIL, after seven years of effort, **will enable at least 200,000 hectares to enter crop production in Colombia**.

• INTSORMIL/ICRISAT male-sterile pearl millet line, 79-2068A, was the leading seed parent of high-yielding, disease-resistant hybrids grown in the low-rainfall areas of northwest India until changes in disease pressures broke down the line's resistance. INTSORMIL research at Kansas State University already had begun to incorporate new resistance into similar parental material. Tests have shown that this new line (81-1163) shows great promise as a ready replacement for 79-2068A.

... and benefits to the United States

INTSORMIL research also finds its way back home to enrich farmers, fields in Texas, Indiana, Mississippi, Kansas and Nebraska, where pearl millet is being developed as a high-protein feed grain to help diversify cereal production.

• INTSORMIL research at Texas A&M has resulted in the release of sorghum lines resistant to biotype E greenbug (10), and the sorghum midge (22). These pests have plagued sorghum farmers for years, **causing an estimated $10,000,000 annual loss in the U.S. alone.**

• While the U.S. sorghum industry produces mostly feed, white or tan food-quality sorghums are in demand throughout Asia and Africa. **The production of light-colored food sorghums developed by INTSORMIL could enhance export opportunities for the United States.**

• An INTSORMIL millet variety that was derived from West African, East African and Indian germplasm is being readied for release in western Nebraska, where hot dry summers and short seasons limit feed grain potential. Pearl millet outyields all sorghum in those conditions and continues to grow even at midday when sorghum shuts down.

• During the severe 1990 drought in Sudan, experimental hybrids, resulting from crosses between INTSORMIL yellow endosperm males and post-flowering drought resistant females, showed excellent drought resistance and performed extremely well. **These lines have the potential of becoming a major source of drought-resistant sorghum in Africa and the United States.**

INTSORMIL

University of Nebraska-Lincoln, 54 Nebraska Center, Lincoln, NE 68583-0948

Phone (402) 472-6032, FAX (402) 472-7978, CGNET 57:CGI025, Telex 438087

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

An initiative of the Agency for International Development, Grant: DAN-1254-G-00-0021-00, Title XII, and the Board for International Food and Agricultural and Economic Cooperation (BIFADEC), participating U.S. universities and collaborating host country institutions.

recycled paper