ICRISAT West and Central Africa

2008 Research Highlights

ICRISAT
Science with a human face

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that does innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help empower 644 million poor people to overcome hunger, poverty and a degraded environment in the dry tropics through better agriculture. ICRISAT belongs to the Alliance of Future Harvest Centers of the Consultative Group on International Agricultural Research (CGIAR).

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Message from the Director General

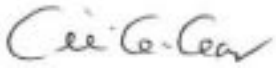
Change is the law of life. ICRISAT believes that in order to 'seize the moment' in the future we have to anticipate potential changes today. Since its 2004 External Management Review and External Program Review, ICRISAT has taken major steps to invigorate and empower its regional hub in West and Central Africa (WCA), making more human resources available and disbursing extra financial resources. We have also improved our research and administrative infrastructure. The recent 2008 External Program and Management Review acknowledged ICRISAT's strong commitment to finding win–win scenarios that will magnify its impacts in Africa.

Despite this positive evaluation, we know there are more challenges – as well as opportunities – ahead, such as those posed by climate change. Also, the reforms taking place in the Consultative Group on International Agricultural Research (CGIAR) call for us to re-engineer ourselves in order to seize opportunities to help the poor in the WCA semi-arid tropics. In this way we can help make possible a grey-to-green revolution.

ICRISAT-WCA plays a key role in enabling farmers to take on these challenges and in catalyzing the necessary changes. It remains a strong partner in the region, reducing poverty through impact-oriented agricultural research. ICRISAT will further expand its influence in the region through strengthened capacity building.

Our partnerships with the CGIAR and sister centers, national programs, rural development agencies, agricultural research institutions, universities, civil society organizations and private enterprise have brought in additional human resources to complement our internal expertise, while others have provided additional financial resources and promoted the use of new technologies. In 2008, donors once more reaffirmed their trust in us and enabled us to continue our impact-oriented research. For this we are grateful.

This report highlights the work carried out in 2008 and reflects the dedication of the scientists, technicians, and support staff who as a team strive to improve the well-being of the poor in the semi-arid tropics of West and Central Africa.



William D Dar
Director General

Message from the Director, West and Central Africa

In 2008, we again made major strides in variety development (especially sorghum hybrid development); technology delivery mechanisms through participatory technology selection; participatory varietal selections for sorghum, millet, and groundnut; bioreclamation of degraded lands; enhancing the efficient use of rainwater and nutrients; seed production and delivery schemes; and understanding climate changes and local adaptation strategies. While we are proud of these achievements, we acknowledge the many challenges that lay ahead and recognize that within them also lie opportunities.

We will continue to strengthen and expand research, covering the entire West and Central Africa region, increasing the number of scientists and support staff and collaborating more closely with national and regional organizations. There is a need for biotechnology tools that can overcome some intractable traits, especially in sorghum and millet growth. Therefore, marker-assisted selection will play a more important role in the future. Crop and system diversification offers tremendous opportunities to increase food security, fight malnutrition and offer income-generating options to smallholder farmers. Efforts should continue to focus on the economics of diversification and its sustainability.

The semi-arid tropics region in West Africa is already affected by climate change and will be highly vulnerable to it over the medium to longer term. But as well as creating enormous challenges, this presents the ideal conditions for deepening our understanding of household coping and adaptation strategies, and we aim to offer farmers technologies and innovations to better tackle the effects of climate variability. We have already strengthened our partnership with the West and Central African Council for Agricultural Research and Development (CORAF), the Centre Regional de Formation et d'Application en Agrométéorologie et Hydrologie Opérationnelle (AGRHYMET), the African Centre of Meteorological Application for Development (ACMAD), and other relevant partners to carry out research on adaptation, modeling, and prediction of climate change.

The private sector is still uncertain of the returns on investment offered by agricultural technologies and is even less informed of the production and management of such ventures. ICRISAT will foster the establishment of the Agri-Science Park, an initiative that will provide opportunity for the private sector to incubate farm technologies and become agri-business entrepreneurs. Another example is the West Africa Seed Alliance, a multi-year project funded by the United States Agency for International Development (USAID) and managed by ICRISAT. Through this project many small-scale farmers have found their way into the seed market chain. The goal is to establish a region-wide network through which private seed enterprises and small-scale farmers can benefit from each other.

Capacity building constituted a major activity in the region and our scientists have significantly helped other scientists, technicians, and farmers to capitalize on their existing and newly acquired skills.

I wish to thank our many partners: national agricultural research systems (NARS), CGIAR centers, CGIAR affiliates, farmers' organizations and associations, and finally smallholder farmers without whom our goal, mission, and purpose will never be achieved.

Farid Waliyar
Director, ICRISAT West and Central Africa

Introduction

This report highlights research achievements made in 2008 by ICRISAT and its partners in West and Central Africa (WCA). It focuses on climate change; pearl millet, sorghum, and groundnut crops; soil and water management; agro-ecosystems emphasizing crop diversification; and socioeconomic and policy issues. The report highlights scientific developments in the three major WCA research programs:

- Conservation, management, and enhancement of genetic resources
- Agricultural diversification and sustainable agro-ecosystems
- Improving markets and facilitating institutional innovations.

Each program provides a strategic direction within the context of integrated genetic and natural resource management as well as appropriate capacity building. The main objective is to support the exploration, conservation, characterization, and exchange of plant genetic resources, specifically of pearl millet, sorghum, and groundnut in the targeted regions of the Sahelian, Sudanian, and northern Guinea savannah zones.

Building resilience in a changing climate

Preparing farmers for climate change

Climate change is a fact. The scientific communities and farmers in West Africa must develop new coping strategies. In this context, we launched the 'Community Management of Crop Diversity to Enhance Resilience, Yield Stability, and Income Generation in Changing West African Climates (CODE-WA)' project in 2008. Funded by the German Ministry for Economic Cooperation and Development (BMZ), its major objective is to prepare farmers in the West African dry eco-zones of the Sahel and Sudan for the effects of climate change.

Based on statistical evaluations, ICRISAT scientists do not see a sound trend for decreasing rainfall or shorter seasons during the last decade, but the real challenges are the variable onset of the season and intra-seasonal droughts. So we cannot rely only on short-cycle varieties; we also have to increase overall diversity. A spectrum of varieties can better adapt to whatever the season brings than one single landrace. Through its breeding and diversification programs, CODE-WA offers farmers a range of crops and varieties that can be tested and compared to local varieties in a participatory manner over 3 years.

But introducing new crops and varieties into the farmers' environment is not the project's only activity. One promising new approach is the Vertical Farmer Exchange Visit. CODE-WA works at four sites on a zonal gradient, covering the eco-zones of the northern Sahel to the transition zone of southern Sudan/northern Guinea savannah. Once a year, selected farmers from each member site gather to discuss topics they deem important. ICRISAT and National Agricultural Research System (NARS) scientists act as facilitators, but essentially the farmers function as extension agents for their colleagues and present their own practices, which are based on decades of experience.

Participants of a vertical farmers' exchange visit in Nobere, Burkina Faso

Since the participating farmers come from different climatic zones, their background knowledge and experiences are unique. Farmers from the wetter zones can learn how to adapt to drier situations, and vice versa. One example is the direct comparison of tomato production, which needs drainage during the in-season (cropping on mounds) and irrigation in the off-season (cropping in furrows). The farmers readily adopted the related cropping techniques for experimentation in their respective sites. The farmers also discussed market chain development for pearl millet and fonio (*Digitaria exilis*), hunger crops (which differ from region to region), and the varying perspectives of farmers and scientists with respect to climate change.

Complex problems require simple solutions: Cutting carbon emissions with Occam's razor

In the 14th century, William of Occam is alleged to have said: "*Entia non sunt multiplicanda praeter necessitatem*" – or, to paraphrase, "The simplest solution to a scientific problem is best".[1] Today, the challenges of carbon accounting lend themselves to the application of this principle.

Modeling research conducted on a controlled long-term fertilization trial in sub-humid Burkina Faso has shown that a discrete, yearly two-pool soil organic matter (SOM) model consisting of one stable and one labile component can predict carbon decomposition. In hindcast mode and after parameter estimation, the model performed just as well as the more complex RothC26.3 model for total SOM simulation (there was a +0.2 difference in root mean square error) and showed comparable predictive skill in independent treatments, including those with crop residue incorporation.

ICRISAT has worked on stochastic data assimilation frameworks for monitoring agricultural carbon sequestration since 2001. The goal is to develop methods for monitoring future carbon contracts once this transitional win–win practice becomes an accepted process for establishing certified emissions reduction. The difficulty with carbon accounting is that measurements are subject to errors that are typically larger than the rates of change. At scales amenable to carbon trade (10–100 kha), the fragmented landscapes and irregular management patterns of rainfed crop–livestock production systems combine with errors in measurements (laboratory methods and remote sensing) and errors in dynamic carbon models to create high spatio-temporal uncertainties. Adequate quantification of uncertainty in estimates of sequestered carbon is a prerequisite to verifying contracts and enforcing compliance.

Data assimilation reduces uncertainty by combining models and field observations. Appropriate sampling design accounts for non-linear features of the production system and allows the formulation of simpler models. These simpler models are particularly relevant to the study of SOM dynamics because they decrease the uncertainty of model outputs associated with the inadequate methods available for determining the structure of soil pools based on their turnover. In other words, the prediction of total soil carbon is more an issue of model tractability and ease of computation than a problem of orthodoxy in the treatment of soil physical, chemical or biological properties.

The simpler model developed in Burkina Faso is nevertheless sufficiently complex to deal with the integration of data over patchy contract areas and relevant time-spans. It gives a better understanding of the behaviour of carbon in rainfed mixed systems and is therefore suitable for upscaling and other applications.

If statistical appraisal cannot identify outstanding predictive performance across a set of models, then other evaluation criteria – including simplicity – should be considered.

1 "Occam's razor". Merriam-Webster's Collegiate Dictionary (11th ed.). New York: Merriam-Webster. 2003. ISBN 0-87779-809-5. http://www.merriam-webster.com/dictionary/Occam%27s%20razor

Pearl millet adaptation to climate variability

Crop adaptation to the unpredictable environmental variations in WCA can be due to individual buffering of single plants and/or population buffering of the plant stand as a whole.

Individual buffering may be favored by phenotypic plasticity of individual plants. An example is photoperiod-sensitive flowering, which enhances adaptation to a variable beginning of the rainy season. It promotes simultaneous flowering, independent of the date of planting. This reduces bird and insect damage and prolongs vegetative development in early plantings but accelerates growth in late plantings; therefore, it adapts plant development to actual rainfall. Our research on 424 WCA pearl millet landraces revealed that 82 percent of the landraces do show significant photoperiod-sensitive flowering, and that late varieties tend to be more photoperiod-sensitive than early cultivars.

Population buffering can be promoted by heterogeneity in the plant stand for specific adaptation traits. An example is variation in flowering time, which would ensure that during a dry spell not all plants would be affected by drought during the flowering stage, when they are most sensitive. Data gained from full-sib selection trials revealed significant genetic variability for flowering time in WCA pearl millet landraces. The difference of flowering date between the earliest and the latest full-sib families derived from the same landrace ranged from 16 to 39 days.

Both photoperiod-sensitive flowering and intra-varietal heterogeneity for flowering time have evolved in the landraces over thousands of years of natural and human selection. So they must bear an advantage for survival and yield stability. Plant breeders are facing another question: how much photoperiodism and how much intra-varietal heterogeneity are needed to obtain high-yielding, stable varieties under the variable growing conditions of WCA? Understanding these phenomena will help us develop cultivars that can adapt to present climate variability and future climate change.

The science of developing new opportunities for crops

Sorghum: Exploring diversity in the field

Sorghum varieties for poor soil fertility and intensified production

Sorghum is grown under a wide range of production conditions (e.g. high and low potassium) in the Sudanian zone of WCA. The number and diversity of sorghum varieties is very large, with both farmer-selected varieties as well as those produced through population and pedigree breeding methods. This diversity has not yet been examined to see how it can best be used to breed superior sorghum varieties with enhanced yield and yield stability that can both increase productivity and survive in poor soil-fertility conditions. Also, the most effective testing methodology is not yet clear: does each condition need separate testing or would a single testing approach meet both needs?

To answer these critical questions, we created a set of 70 varieties that sampled both farmer-selected landrace varieties of guinea-race origin as well as researcher-bred varieties based on guinea-caudatum and interracial genetic backgrounds. We tested these varieties under high- and low-phosphorous conditions in a collaboration with the Institut d'Economie Rural (IER) at the IER-Kolombada and ICRISAT-Samanko sites between 2006 and 2008. Separate trials were conducted at each site in each year with and without phosphorous fertilization, keeping the nitrogen applications comparable.

The results indicate that specific adaptations to low- and high-phosphorous soils exist (see Fig. 1). So it is essential to conduct variety testing under both environmental conditions to effectively describe the adaptation of new varieties. The fact that most of the highly sensitive varieties were also of guinea landrace origin means that it is unclear whether adaptation to low phosphorous is related to photoperiod sensitivity or to the presence of guinea-race genetic background. It would be useful to further investigate the role of racial background and degree of photoperiod sensitivity in determining adaptation to soil fertility conditions. The studies did confirm, however, the importance of using the appropriate germplasm base when breeding for intensified or low-productive conditions.

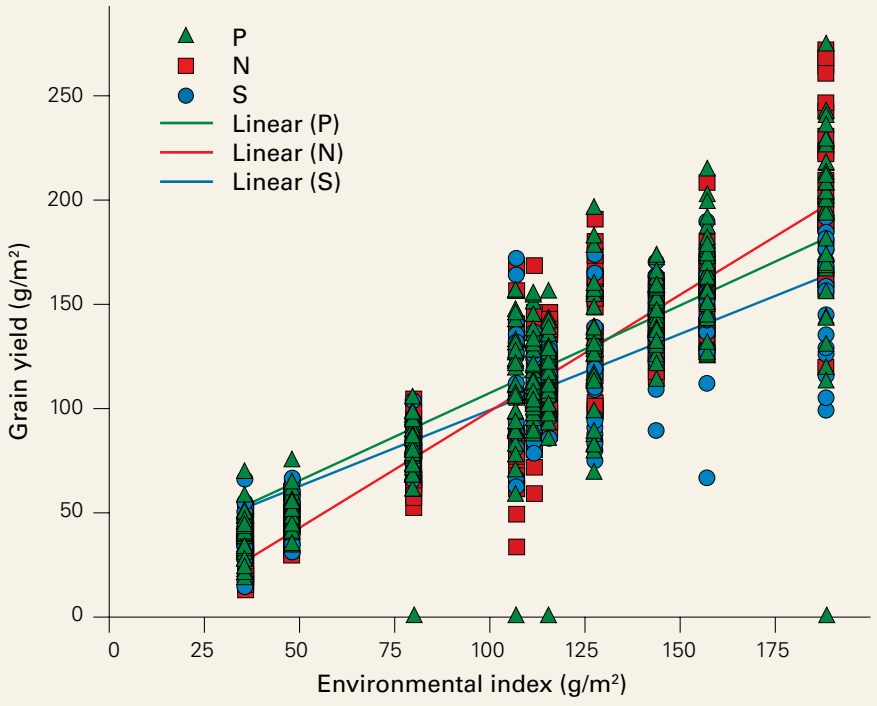


Figure 1. Sorghum varieties for poor soil-fertility and intensifying production conditions

Grain yield responses of photoperiod sensitive (S), intermediate (P) and photoperiod insensitive (N) sorghum varieties to increasing productivity conditions across 10 environments in Mali with mean trial yields used as environmental indices.

Integrated striga and soil fertility management

ICRISAT is using modeling and also innovative on-station, and participatory on-farm research in Mali, Niger, and Nigeria to develop effective, applicable, and profitable integrated striga and soil fertility management (ISSFM) strategies for sorghum and pearl millet.

On-station research is carried out to determine the effectiveness of single and combined control techniques to increase crop yields and decrease striga seed bank densities. Results from 3 years of trials on sorghum indicate that there are clear benefits to combined control. From simulations it appears that rigorous control of striga seed production is necessary to prevent striga population explosions and eventual damage to crop yields.

The ultimate test for an ISSFM strategy is to have farmers apply and evaluate it themselves in their own fields. ICRISAT uses the Cluster Based Farmer Field School (CBFFS) approach, which provides a platform for farmers, facilitators, and scientists to exchange knowledge, develop practical ISSFM strategies, observe the efficacy of striga control, and evaluate an ISSFM strategy in agronomic and economic terms. We are currently analyzing and combining on-station and on-farm data to understand and learn to overcome the technological, cognitive, and socioeconomic obstacles to applying integrated striga and soil fertility management (see Fig. 2).

Sorghum hybrid development

Research on sorghum hybrids in 2008 pursued twin objectives:

1. To provide 'proof of concept' for hybrids that combine desirable grain traits with increased grain yields in the Sudanian zone
2. To create the foundation for viable hybrid development in the region.

A first series of hybrid parents has been developed jointly by ICRISAT and IER. These possess the grain shape, glume shape, and panicle types required in this zone by using guinea landrace and guinea-caudatum interracial source materials. We have provided approximately 100 experimental hybrids and 20–40 advanced hybrids

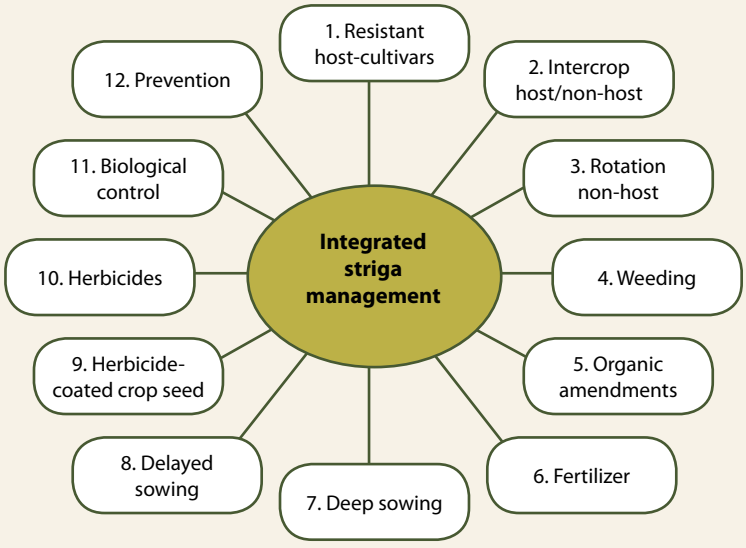


Figure 2. Integrated striga and soil fertility management

Field infested with striga

based on these hybrid parents to NARS annually since 2005 for initial evaluation and yield testing. Participating countries include Burkina Faso, Ghana, Mali, Niger, Nigeria, and Senegal. Three hybrids have been released in Mali in collaboration with IER and are all under seed production within the private sector; two more are being developed.

Hybrids frequently show grain yields that are 40 percent higher than the well-adapted local checks in both on-station and on-farm testing. For example, on-farm results from 2008 showed that the hybrid 'Fadda' had a 38 percent yield superiority (3240 kg/ha compared to 2360 kg/ha for local check varieties) under higher productivity conditions and a 32 percent yield superiority (1590 kg/ha compared to 1200 kg/ha for local checks) under lower productivity. This hybrid was among the first four to be registered in Mali that were based on these new parental lines.

Our research suggests that heterotic groupings may be based on geographic origin, with Sudanian-zone materials possibly serving as the seed–parent pool and Guinean-zone and southern African germplasm for the restorer pool. Results of current and published molecular diversity studies suggest that these groups are genetically distinct. There is still a need to:

- Further define functional heterotic groups for WCA sorghum hybrid breeding, as well as parental germplasm pools based on these groups with short plant height and desirable grain type
- Increase local capacity for production and marketing of hybrid seeds
- Ensure assessment of genotype by environment interactions for hybrids, particularly regarding soil fertility
- Design effective breeding strategies for the diverse production conditions.

Pearl millet: Mapping diversity at the molecular level

WCA is the main centre of origin and diversity of pearl millet, but this diversity has been neither well understood nor fully accessible and efficiently used by plant breeders and farmers. Characterization of this diversity is improving the efficiency of plant breeding efforts to exploit these crop genetic resources to develop higher yielding pearl millet varieties with more stable on-farm performance. However, the expression of much of the visible variation within and between existent pearl millet varieties depends on the conditions in which these varieties are grown. This means that expensive and time-consuming multi-year, multi-location field evaluations are needed to adequately assess the underlying genetic variation so that relationships can be characterized and exploited by plant breeding.

Fortunately, molecular markers (typically based on DNA sequence variation that is largely unrelated to morphological variation) can provide information on

genetic relationships within and between varieties that is not dependent upon the environment in which they are assessed, reducing the time required to assess these relationships. One of the most useful types of molecular markers is referred to as 'simple sequence repeats' (SSRs), and these are now widely used for characterizing genetic variation in crop plants.

Heterotic grouping of pearl millet landraces

The main activity of the pearl millet improvement program has been to identify heterotic groups among WCA pearl millet landraces and breeding materials. This is done through the study of agro-morphological differentiation, genetic diversity at the DNA level using molecular markers, and evaluation of population hybrids representing putative inter- and intra-pool crosses. The molecular marker diversity analysis, which is done in close cooperation with the high-throughput marker laboratory at ICRISAT-India, revealed that pearl millet genetic differentiation in WCA largely follows geographic origin of the landraces – that is, landraces from Senegal are distant from those of Niger and Nigeria – while accessions from Mali and Burkina Faso lie in between. So we created putative intra- and inter-pool crosses using a parental population of diverse geographic origin (from Senegal to Sudan and from Mauritania to Central African Republic) and evaluated the crossing progenies together with the parents and checks in multi-location trials in Burkina Faso, Mali, Niger, Nigeria, and Senegal.

We conducted a total of 10 different trials involving diallel or factorial crosses during the years 2006–2008, with materials grouped into extra-early, early-to-medium, and later maturing classes. We then evaluated these in their respective zones of adaptation (northern Sahel, southern Sahel, and Sudanian zone, respectively).

The concept of heterotic groups is now being applied and refined in both breeding of open-pollinated population and hybrid varieties, to serve farmers with new, outstanding and stable cultivars.

Mobilizing regional diversity: Molecular diversity patterns observed in WCA pearl millet

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is the staple cereal grain of the hottest, driest regions where rainfed agriculture is still possible in sub-Saharan Africa and South Asia. It is also grown in more humid regions on light-textured soils that have low fertility and water-holding capacity, low pH, and/or high levels of aluminum saturation. This stress-tolerant crop is better adapted than other cereals to these harsh environments. Pearl millet landrace varieties (developed by farmers and their ancestors over the past 5000 years) and improved open-pollinated varieties (developed by plant breeding programs over the past 50 years) are highly variable and exhibit tremendous differences in traits such as flowering time, plant height, and yield components such as panicle numbers, panicle size, and grain size.

During the project Mobilizing Regional Diversity, we characterized the relationships of 199 pearl millet accessions from all over WCA using 16 SSR markers. After isolating bulk DNA from a representative sample of seedlings of each accession (based on seed lots used

Farmers in millet field in Burkina Faso

for field characterization studies), each of the 199 DNA samples was characterized with these markers. We detected a total of 117 marker variants.

We then calculated the relationships between the pearl millet accessions based on differences in marker variants present for each pair of accessions. The most similar pair of accessions were two medium-early flowering landraces from Niger with very long panicles, and the two least similar accessions were the extra-early flowering landrace 'Nata' from Burkina Faso and an early flowering landrace from Mali. We then produced graphical displays of the relationships between accessions (for example, neighbor-joining trees). When combined with passport information, field characterization information for each of the 199 pearl millet accessions, and/or information on performance of crosses between these accessions, such graphical displays improve our understanding of the genetic relationships between the accessions and the opportunities for exploiting them in applied plant breeding.

Geographic differentiation

Color-coding a tree of marker-based relationships by geographic origins of the pearl millet accessions reveals patterns of their geographic differentiation (see Fig. 3). Landrace accessions from Benin and Niger each tend to form a relatively compact group, and a third group includes most of the accessions from Mauritania and Senegal (interspersed with some from Burkina Faso), whereas accessions from Burkina Faso, Mali, and Nigeria and improved open-pollinated varieties are distributed across several clusters. However, for accessions originating from other countries, the data were too sparse to indentify clear patterns.

Merging results from this marker-based genetic diversity analysis of pearl millets from WCA with those from the multi-location characterization study and from the heterosis studies that were implemented in the course of this project, we generated information that can further improve the efficiency of pearl millet breeding programs that target the harsh crop–livestock production

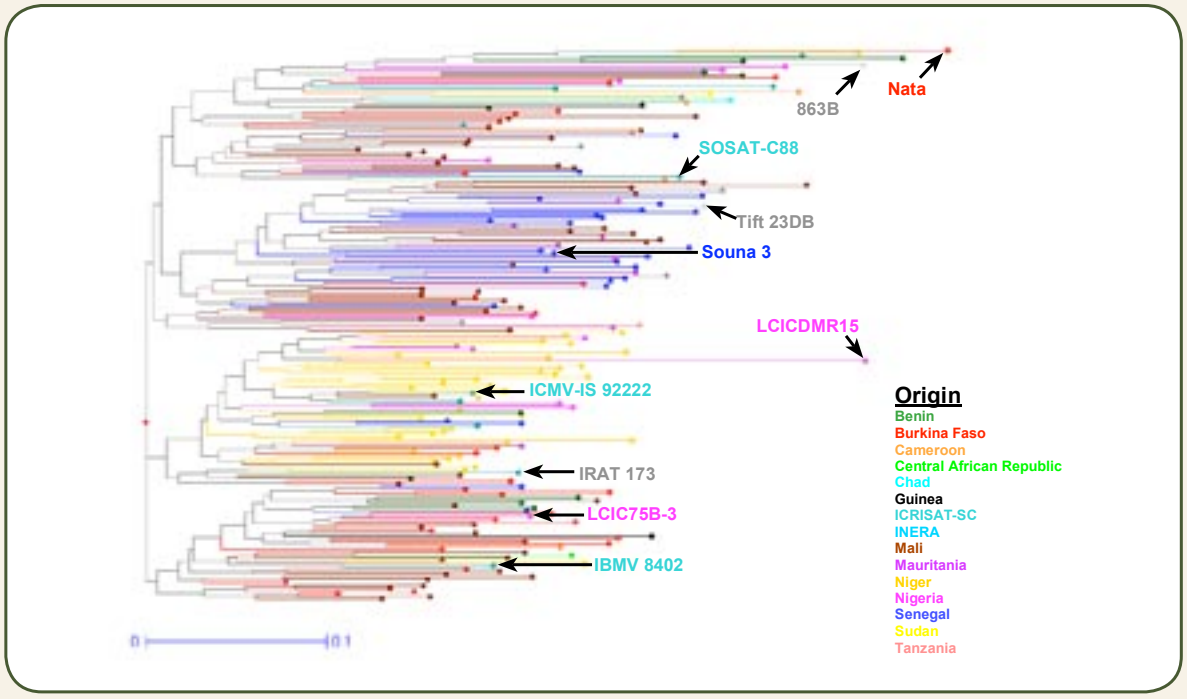


Figure 3. Neighbor-joining tree based on variation detected using 16 molecular markers that shows geographic differentiation of 199 pearl millet landraces and improved open-pollinated varieties from WCA. Note the positions of standards (Tift 23DB and 863B) and several other accessions.

environments of this region. For example, there are several genetically distinct clusters of accessions in each maturity class that might be used to form heterotic groups for breeding higher-yielding hybrid pearl millet varieties for present and future pearl millet production environments in WCA. In contrast, most of the accessions with very long panicles appear to be closely related (and are primarily landrace accessions from Niger). Now we need to convert this information into knowledge that we can use to breed better pearl millet varieties and hybrids that will meet farmers' needs throughout WCA.

Groundnut: Selecting for resistance and high yield

Enhancing groundnut productivity and production

Several activities were aimed at identifying groundnut varieties with farmer- and market-preferred traits as well as enhancing NARS breeding resources in Mali, Niger, Nigeria and Senegal. A main requirement in this context was to get an overview of the structure, conduct, and performance of formal and informal groundnut seed supply systems in the four countries. This information has been published. Some other activities and outcomes include:

Scientist and farmers in a groundnut field in Nigeria

- Farmer participatory variety selection (PVS) of 39 improved groundnut varieties resulted in the selection of 17 varieties having farmer-/market-preferred traits. Of these, 13 have been released and 23 are in the pre-released stage. We intensified the scaling up and out of PVS in other locations in Mali, Niger, and Nigeria in 2008.
- Farmers using best-bet harvesting and drying techniques and tolerant varieties are producing groundnuts with minimal aflatoxin contamination.
- In order to enhance NARS breeding resources, we made available 300 new breeding lines with multiple traits (77 in Mali, 45 in Niger, and 178 in Nigeria) for further selection by the respective national programs.
- Under the 'Tropical Legumes I' project, 268 cultivated accessions of the reference collection were assessed in Mali (together with 12 local varieties) and in Niger (along with nine varieties from the collection of ICRISAT-Sadoré) for tolerance to early leaf spot disease and drought-related traits (yield, harvest index, and transpiration efficiency) to identify tolerant/parental material to use in generating new breeding populations for marker-assisted breeding.
- At ICRISAT-Niamey in Niger, drought-related traits assessment was conducted following the rainy season in pots for transpiration efficiency (TE) and in the field for yield and harvest index (HI). In the potted experiment, there was a wide range of variation for TE among the accessions. Significant differences were also observed among the accessions with regard to yield and HI in field experiments. Yield reduction under stress ranged from as high 80 percent to as low as 25 percent. About 10 accessions, including one short-duration variety popular in Niger and Nigeria (RRB), recorded the lowest yield reduction under moisture stress. Overall, five accessions recorded both high HI and TE under moisture stress.
- In Mali, 53 new crosses were made to generate new breeding populations with multiple attributes, including foliar disease resistance, rosette disease resistance, productivity, and tolerance to aflatoxin contamination.

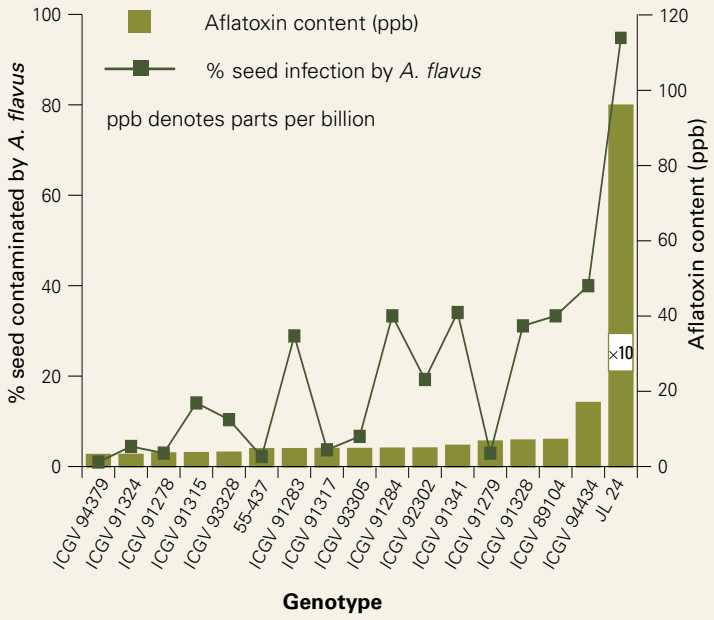


Figure 4. Evaluation of groundnut breeding lines for resistance to *A. flavus* and aflatoxin

Aflatoxin management: Looking for a higher level of resistance

In 2008, we undertook both the screening of mini-core collection for resistance to *Aspergillus flavus*/aflatoxin and the testing of breeding lines with higher levels of resistance.

The testing of 15 breeding lines introduced from India indicated that among them several had very good adaptability to the environment at Sadoré and the yield performance was better than the best-improved varieties (see Fig. 4). ICGV 94434 produced the highest yield (3.1 t/ha). Seed infection by *A. flavus* varied between 2.2 percent (55-437) to 94.81 percent (JL 24). Four introduced lines had less than 5 percent seed infection. Aflatoxin contamination varied from 2.9 ppb (ICGV 94379) to 956.86 ppb (JL 24). Interestingly all resistant lines except ICGV 91283 (0.893 t/ha) gave high pod yields.

A trial of 180 groundnut mini-core varieties and four controls, including two resistant (55-437 and J11) and two susceptible varieties (Fleur11 and JL 24), were conducted at Sadoré to evaluate their resistance to *A. flavus* and aflatoxin. The percentage of seed infection by *A. flavus* varied from 5.19 percent (ICG-36) to 100 percent (ICG-14482) Among the 180 genotypes tested, 20 were resistant with less than 10 ppb seed aflatoxin content. Out of the 184 tested varieties, 41 varieties showed less or equal aflatoxin content than that of the resistant control J11 (7.2 ppb). The very highly contaminated genotype was ICG-11482, with 4703.4 ppb aflatoxin.

Management of aflatoxin contamination

Several management practices have been developed and tested in the region. Agronomic practices to minimize risk of pre-harvest infection by *A. flavus* were tested in two regions of Mali (Kays and Kolokani) These technologies included the application of lime, farmyard manure, crop residues, and their combinations using aflatoxin-resistant (55-437) and susceptible (JL 24) cultivars. The application of lime and farmyard manure significantly reduced aflatoxin contamination, especially in the susceptible cultivar. The application of lime alone reduced aflatoxin by 79 percent. When combined with farmyard manure, the reduction was over 95 percent. Some components of these technologies are now being tested for further scaling up.

Soil, water, and nutrients: The right balance

Enhancing rainwater and nutrient-use efficiency

This 5-year project, which started in 2004, is funded by the Challenge Program on Water and Food (CPWF). It is designed to address the major constraints encountered by small-scale resource-poor farmers in the Volta Basin, using a systems approach that integrates water-use efficiency, soil and nutrient management, and improved germplasm, together with market opportunity identification and capacity building in rural communities.

We carried out several on-farm trials in Burkina Faso and Ghana:

- Integrated soil–water–plant–nutrient management or Savannah/Sahelian Eco-Farm (SEF)
- Fertilizer microdosing
- Combined rainwater and nutrient management
- Soil degradation control.

Results from previous years showed increased crop yields from the improved technologies. Soil amendment with tied-ridging for micro-catchment and water harvesting held the greatest promise. Conventional tillage with soil amendment was shown to be the best management option for high crop yields. The fertilizer microdosing technology increased nitrogen-use efficiency by up to 50 percent. Yield prediction from now until 2035 using the Decision Support System for Agrotechnology Transfer (DSSAT) showed that, the amount and distribution of rainfall poses a high risk to efficient use of mineral fertilizer on soils with low organic matter. The program enabled us to build a diverse and strong partnership between international agricultural research centers (IARCs), NARS, agricultural research institutes (ARIs), non-governmental organizations (NGOs), and rural communities. We also trained several scientists and technicians in the use of DSSAT modeling for evaluating technologies under varying management conditions.

Combining water harvesting and nutrient management

Together with various stakeholders including NARS, NGOs, farmers' associations and the private sector, we developed improved integrated soil, water, and nutrient management technologies in the period between 2005 and 2008. Our main objective in this CORAF/African Development Bank-funded project was to further evaluate and promote these technologies in farmers' fields, thus enabling them to improve crop productivity and yield. The project was implemented in Burkina Faso, Mali, Niger, and Senegal by a multi-institutional and multi-disciplinary team with the active participation of farmers' associations and extension agents.

More than 150 demonstrations were established in these four countries. Results obtained from these on-farm trials and demonstrations showed that millet and sorghum yields have increased by 40 to 120 percent using integrated water harvesting techniques

Half moon and Ziziphus *tree in Burkina Faso*

such as *zai* or half moon, in combination with fertilizer microdosing. In all project sites over the 3 years, the *zai* system proved the better technique for harvesting water for the production of sorghum, millet, and cowpea; this technique helps to rehabilitate degraded lands. The encouraging results obtained from the combination of water harvesting techniques and fertilizer microdosing appeared to be affordable to the farmers. The Farmers Field Schools approach, in which trained farmers played the role of extension agents, was used to build capacity in other farmers and to scale these technologies up and out. In 3 years of promotion, the integrated water and nutrient management technology and the warrantage or inventory credit system reached more than 1650 rural households in the project study sites, with a doubling of crop yields and revenues.

Fate of nutrients in organic matter subjected to termite activity

ICRISAT-Sadoré conducted this experiment to:

- Study organic matter decomposition in Sahelian soils
- Quantify losses of organic matter and nutrients due to termite activity
- Study the fate of these nutrients with regards to their availability to crops.

Two types of litters (millet straw and cow dung) were used in combination with two types of containers: litterbags (or 'clio' bags) of 2 mm mesh and calico bags of 1 µm mesh. Cow dung decomposition was faster and more complete than millet straw in the larger mesh compared to the smaller mesh size, where decomposition of the amendments was similar. Termites seem to be selective in terms of amendment quality – although earlier studies have shown the opposite. Still, amendment decomposition in the presence of termites does not mean the microorganism has a higher influence because in the smaller mesh size decomposition was similar for both amendments. We observed a delay in the decomposition process after litter exposure, which could also explain the termites' preference for cow dung.

Farmers' graduation day in Navrongo, Ghana

Nitrogen (N), phosphorus (P), and potassium (K) followed similar trends in amendment decomposition. The end results showed:

- K release was complete in the larger mesh size, while on average 50 percent remained in the smaller mesh size.
- N and P release: an average of 20 percent remained in the larger mesh size in contrast to 60 percent on average for the smaller size.
- No effect on nitrate leaching even though N released from cow dung was higher.

Crop diversification: A myriad of approaches

Irrigation: The African Market Garden

The African Market Garden (AMG) is a horticultural production package based on low-pressure drip irrigation. It integrates and optimizes all aspects of production, socioeconomics and marketing into one system aimed at enhancing nutrition and the profitability of smallholder vegetable producers. Drip irrigation improves growing conditions while at the same time saving water, labor, and energy (see Table 1). Vegetable producers have access to a variety of ICRISAT/World Vegetable Center (AVRDC)-selected crops that allow them to grow improved vegetables year-round. Training and follow-up are other critical elements of the AMG technology. Some promising elements of the AMG are:

- AMG producers can make a profit of around US$1000 per year from 500 m^2, depending on their access to credit, markets, and knowledge of crop husbandry.
- Cluster and communal AMG models can be developed to facilitate uptake of the AMG technology for credit-constrained farmers' cooperatives or women's groups.
- Profitability can be increased by looking for environmental and cost-effective alternatives for motorized pumps, fertilizers, and pesticides (e.g. solar-powered pumps and artesian boreholes).

Table 1. Returns to land, labor, and water from lettuce production in 500 m^2 African Market Garden using drip and watering can compared to traditional farmers' practice

Return to	Unit	AMG-drip	Watering can	Farmers' practice
Land	US$/$m^2$	1.8	1.0	0.8
Labor	US$/whr*	6.0	1.5	1.0
Water	US$/$m^3$	8.4	4.7	2.7

* US$/whr denotes US dollars per work hour

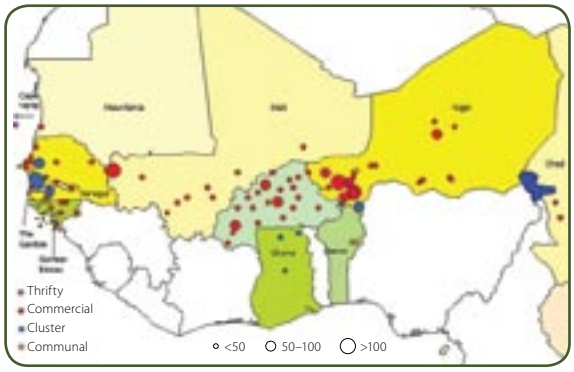


Figure 5. Map showing location and number of AMG installations 2000–2009

Reclaiming degraded lands

In 2006 ICRISAT established an innovative technology for reclaiming severely degraded abandoned farmlands in West Africa to successfully bring them back into profitable agricultural production. Bioreclamation of Degraded Land (BDL) is an integrated system aimed at increasing food production, nutrition, and income for women through the use of degraded lands for production of rainfed fruit trees and vegetables. In the BDL experimental field, we are testing water- harvesting technologies and crops and recording their performance and calculating soil moisture and nutrient balance. Also:

- Yield data for traditional vegetables show that *Senna obtusifolia* can produce a yield of 1500 kg of fresh leaves per hectare. The calyx yield of roselle is 450 kg/ha and the fresh yield of okra fruit is 1000 kg/ha.
- Altogether, the estimated annual value of trees and vegetable products can amount to US$1200/ha.
- Starting in 2009, we will study the trap cropping system for okra pest control using pigeonpea as a border crop, in collaboration with the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD). A socioeconomic study of the system will give clear ideas on the actual profitability of BDL.

The integrated agricultural production system

This production system addresses a range of constraints to agricultural productivity in dryland Africa. It combines the use of live hedges and alleys of *Acacia colei* – 'demi-lunes' in which are planted domesticated *Ziziphus mauritania*. Annual crops (pearl millet, cowpea, and roselle (*Hibiscus sabdariffa*) are planted in rotation. We conducted a synthesis of results over 5 years of the study (2004–2008) on the Drylands Eco-farm (DEF) to draw lessons from the research findings.

For example, the average pearl millet yield was twice the control yield in the DEF when no mineral fertilizer was applied. With the application of N–P–K (15–15–15), millet yields were similar under both conditions. When observed on an annual basis, crop yield decreased in general in the DEF as well as in the traditional system to reach 200 kg/ha in the DEF in 2007 for pearl millet. However, in 2008 a slight yield increase was observed again. The crop yield was always higher in the DEF compared to the traditional system.

We presume that crop set-up at the beginning of the season could be one of the reasons for this general trend. The planting time was highly variable, due to the varying onset of the rainy season but also to a dry spell that delayed planting. We're continuing to research the system to better understand which factors induce this yield decrease with and explain the slight increase in soil fertility after 4 years.

Diversifying tree crops for food production, nutrition, and income

ICRISAT's crop diversification program is engaged in domestication research on important fruit trees at the Sadoré station. We have obtained valuable results during the last 3 years on *Z. mauritiana* (commonly known as the Sahel apple) and *Saba senegalensis*, one of the most promising indigenous fruits in the region. Results from the evaluation of fruiting performance of five improved *Ziziphus* spp. varieties show:

- The fruit yield of 3-year-old trees ranged from 17 kg to 25 kg per plant under drip irrigation and from 6 kg to 10 kg under rain-fed conditions with annual rainfall of 400–500 mm/year.

Measuring of Ziziphus *rootstock at ICRISAT's Sadoré station in Niger*

- The local *Z. spina Christi* has been identified as the best rootstock for multiplication of improved varieties. It has showed a high performance in adaptation to drought and good success rate (65 percent) with grafting.

The promotion of non-traditional cultivated fruits and vegetables is an important component of the crop diversification program. Considering the tremendous potential of *S. senegalensis*, we have taken the initiative to domesticate it:

- *Saba* sp. plants started producing fruits 2 years after planting. Phenology data indicate that flowering occurs all year round, with a peak period in June. Fruits mature only in July/August after a long period of development, which can last for 12 months.
- Fruit production per plant varies remarkably, ranging from 100 g to over 8 kg.
- The mean weight of fruits is about 200 g, with pulp representing 20 to 30 percent of the fruit weight.

The large variability in fruit size, shape, yield, and quality indicates a great potential for *S. senegalensis* domestication.

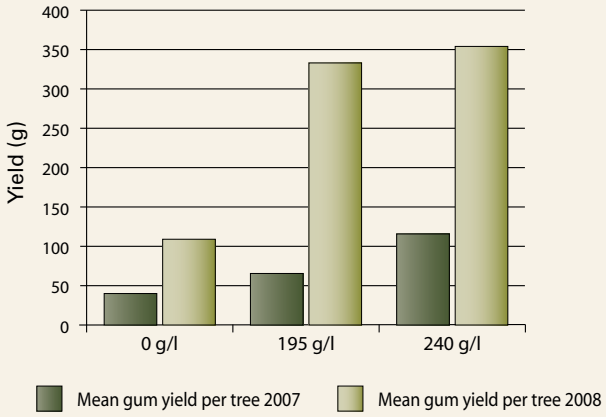


Figure 6. Gum yield in *Acacia senegal* with injection of chloro-ethyl-phosphonic acid (ethephon)

Acacia senegal *tree in Niger*

ICRISAT research on *Acacia senegal* aims to increase the gum yield per tree in order to improve the profitability of the plantations. The results obtained from 4 years' research show:

- Through selection and proper tree management techniques, gum yield per tree can be greatly improved.
- Mean production of identified elite trees varies from 500 g to 900 g, compared to an average yield of 350 g per tree.
- Injection of chloro-ethyl-phosphonic acid (ethephon) improves gum yield per tree by up to three times (see Fig. 6).

Research in the field of alternative energy and biofuel focuses on selection for improved fruit yield and adaptation of *Jatropha curcas* varieties to various agro-ecological conditions, as well as on developing suitable agronomic techniques to enhance seed yield while improving the sustainability of the production systems:

- We have established a reference collection of *J. curcas* germplasm that includes at present 26 accessions from many parts of the world.
- Preliminary results indicate that variability within accessions is highly pronounced, showing a mean tree yield ranging from 0 kg to 1.7 kg.
- We are currently investigating water and nutrient requirements, spacing, and pruning regimes.


NIGERIA

Adoption studies: Where technologies are heading

Our goal in these studies is to help generate policy options, tools, methods, lessons, and investment strategies. This program contributes largely to the other programs, especially when socioeconomic studies are needed. It helps scientists to evaluate their research impact in the region and to base their work on solid socioeconomic background knowledge. Over the last 3 years, the research agenda has been focused on six key areas:

- Strategic assessment of agriculture and economic growth in the WCA semi-arid tropics
- Poverty dynamics and development pathways
- Markets and commercialization
- Seed systems
- Crops and natural resource management
- Adoption and impact studies.

Since 2006, we have undertaken five adoption studies on groundnut and pearl millet varieties in Mali, Niger, Nigeria, as well as three studies on uptake of soil and land management in Burkina Faso, Mali, and Niger. The groundnut market prospects in international, regional, and domestic markets and the structure and performance of groundnut seed market are thoroughly understood by ICRISAT scientists. The results are manifold and are available in relevant publications.

Under the 'Tropical Legumes II' project, we undertook baseline data collection in Mali, Niger, and Nigeria. Overall, 240 households were surveyed in Niger and 280 each in Mali and Nigeria. These datasets form an essential base to better assess the impact of groundnut varieties on the livelihood of the poor.

The seed market has become an important issue in WCA when talking about agricultural development and hence research. We conducted pilot testing for small pack seeds in the Dosso region of Niger in 2007/08 that revealed that more than 1500 farmers gained access to new seed varieties through this scheme. Overall, the profitability of such an operation was limited: there were 20 percent losses relative to the break-even price. The major constraints identified were: poor positioning of input shops and outlets, little or no business and marketing skills, and limited information on the varieties. This operation will continue in the 2009 cropping season but with the addition of significant training in business and marketing skills for partners.

An assessment study on farmers' preferences for groundnut plant and seed traits was undertaken in Mali, Niger, and Nigeria during the 2007/08 cropping season. At three stages of plant growth (plant establishment, flowering, and harvest), we selected a range of panelists in each country to provide their perception on plant and seed traits on varieties tested under the mother trials in the Tropical Legumes II project. In each country, these preference surveys were implemented with partners who were trained before. Data for Niger and Nigeria have been entered and explored; data from Mali are forthcoming. We have prepared preliminary results for presentation during the review and planning workshops organized prior to the 2009 rainy season.

Seed stock of a farmers' cooperative in Sikasso region, Mali

Sustainable land management for climate change adaptation and mitigation in Niger

Results from a Participatory Rural Appraisal (PRA) in eight villages in the Tahoua region in Niger indicate that farmers are adapting in many ways to changes in climate by using different agronomic practices, changing livestock-rearing schemes, and looking for non-farm opportunities such as labor migration.

Farmers' perceptions on the impacts of climate change may not be consistent with scientists' investigations. Collected rainfall data in the Sahel show that during the last decade the quantity of rainfall has actually increased. But according to farmers the contrary has occurred: they say there is less rain, the growing period is shorter, and the rainy season starts later and ends earlier. Other indicators include:

- Shallow water table levels are dropping lower
- Wells are drying up
- Bird species and wild animals are disappearing
- Land degradation and soil infertility are more severe
- Tree species are disappearing
- Grazing land is becoming scarce, causing conflicts between herders and producers.

However, in villages where there has been significant investment in soil and land management projects, farmers have centered strategies towards vegetable and fish production. Results from the PRA will be confirmed using a structured survey of households in the Tahoua region.

Food consumption survey and the potential impact of biofortification

We conducted a food consumption survey in two zones of southern Mali during the dry (May) and rainy (August) season in 2008. Our objectives were to describe food consumption patterns of young children and their mothers in farming communities in Mali and to estimate the potential effect of biofortified sorghum on total iron (Fe) and zinc (Zn) intake. Researchers measured dietary intake by weighing all foods consumed by children (aged 12–24 months) and their mothers during one day and calculated nutrient intake based on the food composition table of Mali.

The main results showed:

- Cereals are the main contributors to energy, Fe and Zn intake
- The average Fe intake for children and mothers was 3.4 and 13.7 mg/day respectively, whilst recommended Fe intake for children is 11.6 mg/day and 30–58.8 mg/day for women.[2]

Estimates of the potential impact of biofortified sorghum on Fe and Zn intake showed that in order to increase the intake of these nutrients in children by 50 percent, the Fe and Zn values of the biofortified sorghum should be roughly 3.3 times higher than in local varieties. Due to a relatively higher cereal consumption of mothers, a 50 percent increase in Fe and Zn intake can be achieved with a mineral concentration 2.5 times higher as compared to local varieties.

On-station variety trials have shown promising results, and the best identified varieties can reach a near 50 percent increase in Fe and Zn intake. However, although this is a step in the right direction, more effort is needed to reach adequate nutrition for these nutrients (see Fig. 7).

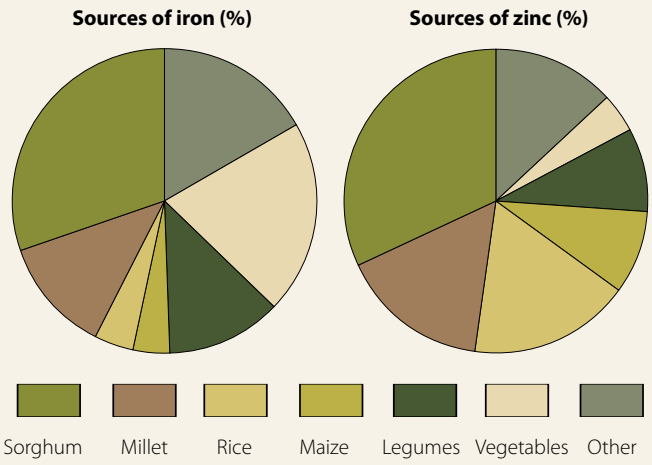


Figure 7. Percentage contribution of various crops and other sources to overall iron and zinc intake in a typical WCA diet

2 Food and Agriculture Organization of the United Nations and World Health Organization. 1998. Vitamin and mineral requirements in human nutrition: Report of a joint FAO/WHO expert consultation held in Bangkok, Thailand, 21–30 September 1998.

Women in Bougoula, Mali, dancing after a successful Open Field Day organized by WASA

The West Africa Seed Alliance

Despite significant donor and private-sector investments in seed sector development in West Africa, most smallholder farmers in the region are unable to access quality seed of improved varieties, and the development of the seed sector lags behind eastern and southern Africa.

The USAID-funded Seeds Project that supports the West Africa Seed Alliance (WASA) helps develop viable seed and other agricultural inputs systems and supports the overall growth of the West Africa agricultural sector. Its goals are to:

- Create a sustainable commercial seed industry that ensures small-scale farmers have affordable, timely, and reliable access to high-quality seeds and planting materials
- Play a leading role in the growth and development of viable agricultural inputs systems, thus supporting the overall growth of the West Africa agricultural sector
- Improve the agricultural enabling environment.

The Seeds Project is jointly implemented by ICRISAT, CNFA and the Seed Science Center-Iowa State University (SSC-ISU), known as the 'ICRISAT Team'.

The development of an effective alliance takes considerable time and effort that goes beyond the development and implementation of a conventional project. USAID has shown considerable flexibility in funding and provided valuable support that is very much appreciated both by the implementing and resource partners.

The Seeds Project is working closely with AVRDC in the testing of commercial vegetable varieties that will be marketed through the agro-dealer network being developed by CNFA; with the Tropical Legumes II project for commercialization of legumes crops including cowpea, groundnut, and soybean; and with other centers like the Africa Rice Center that has received funding for promotion of 'Nerica' under the USAID Global Food Security Response.

In pursuit of its goal, WASA conducts a range of activities like agro-dealer training, demonstration plots, farmer field days, quality management training

Farmers in a sorghum field during a Farmers' Field Day in Nigeria organized by WASA

with private companies and the public sector, quality control for foundation seed production, and geographic information systems mapping.

The Central Advisory Service on Intellectual Property of the CGIAR is using WASA as a case study in the application of systems dynamic modeling and the use of branding to improve seed quality and increase the attractiveness of publicly developed varieties for commercialization. ICRISAT has also provided a grant to Rutgers University through the USAID-linkage fund to work with WASA on the development of indicators to track the evolution of commercial seed enterprises. These collaborative efforts are important to draw lessons that will become international public goods, which are urgently needed across the continent as policy makers' grapple to develop more effective public–private partnerships.

WASA in Mali

Creating a West African seed market that begins to act as one large, unified market instead of fragmented national markets offers tremendous opportunities for NARS and local seed companies. Therefore, the ICRISAT Team is prioritizing the distribution system, focusing the bulk of USAID-funded efforts on strengthening local seed companies and agro-dealers, thereby helping the new varieties and technologies developed by NARS to reach producers.

Product knowledge pays off

Molobala is a typical village in the Koutiala region of Southern Mali near the Burkina Faso border. It can only be reached by taking a poorly maintained dirt road for 25 miles from Koutiala town. Molobala village consists of some 300 houses, most of which are built of mud bricks. The village has a handsome mosque built in the traditional style of the Sahel region. The villagers live mainly off the land, cultivating maize, sorghum, millet, groundnuts, and vegetables. As is common in the region, cattle play an important part in the survival strategy of the population. Bullocks and donkeys are used for transport and land preparation and can be sold for cash when times are lean and crops cannot offer food security for the family. Almost all villagers keep goats, sheep, and poultry.

Mr Bakan Koroma (26 years old) and his wife started a small shop selling necessities such as matches, candles, and soap a few years ago. They were asked by their fellow villagers to bring some veterinary products from Koutiala to treat common cattle conditions such as internal and external parasites. So Mr Koroma started selling veterinary products to villagers, often one pill at a time. For small communities such as Molobala, where the nearest veterinary service is 45 kilometers away, small agro-input suppliers like Mr Koroma provide a vital service.

One of WASA's roles is to facilitate the training of small agro-input dealers to increase their technical skills and product knowledge. So we invited 13 agro-dealers like Mr Korama to participate in a training session provided by a local manufacturer of veterinary products. The training covered safe use and handling of veterinary products, the major diseases and parasites, and how to administer the products. For example, Mr Koroma learned that for effective treatment of internal parasites, three pills need to be administered to cows and not just one. After the training Mr Koroma received samples, posters, and a certificate.

We visited Mr Koroma a few weeks after his training and he told us that he is now recognized by the farmers as the village expert on cattle treatment and that 20 farmers have asked him to not only supply the veterinary product but also to administer the medicines to the livestock himself. A little training goes a long way for people like Mr Koroma. They gain confidence in their day-to-day activities; veterinary products and pesticides are handled in a safe and responsible way, reducing risks to the environment and humans; and animal health and farmers benefit from healthier livestock. Mr Koroma is looking forward to more training provided with help from WASA, including business management skills.

Sharing tools and knowledge

Technology dissemination is an essential part of ICRISAT's activity in WCA, both within the overall strategy and as a key method within the single projects. In general, these methods comprise the means to broaden the knowledge and the skills of our target groups as well as to learn about potential structures and strategies of dissemination. Among the methods are: participatory variety selection, community-based seed systems, testing of seed delivery mechanisms, market testing for small packs of seeds, training in seed production and small-scale business skills, Farmer Field Schools and Farmers for the Future. In the end, they ensure that innovations will be made accessible to those who would and should benefit from them. For example, between 2006 and 2008, over 16,775 pearl millet foundation seeds of seven varieties were sold.

The varieties released include:

- Millet variety GB 8735 with high Fe and Zn content
- Five promising millet varieties (new experimental cultivars currently adopted in Mali, Niger, and Nigeria)
- Four sorghum varieties in Mali, two in Nigeria
- Two sorghum hybrids in Nigeria
- 10 groundnut varieties in Mali, Niger and Nigeria
- At least two sorghum hybrids yielding 25 percent more than open-pollinated varieties in Mali

An example that inspires hope: Farmers for the Future

With the Farmers for the Future program, ICRISAT contributes to creating a new generation of market-oriented farmers that are open to innovation and aware of the environment. Near its West Africa center in Niamey, Niger, we are currently testing this program at the primary school of the Sadoré village. Young students put ICRISAT's agricultural technologies into practice through competition and reward for excellence. The program involves 50 children aged 10 to 14 years. The children are provided with a wide range of production systems including a tree nursery, a 1000 m^2 drip-irrigated vegetable garden, 0.5 ha of Drylands Eco-farm, an animal-fattening facility, and a mother plantation of valuable trees. Children are taught how to generate income, process and market their products, save, and invest. The participants all live in the same community and receive similar instructions for the contest.

Perhaps it was the best students in school who succeeded; perhaps it was those who could afford fertilizer and pesticide. Or was it household knowledge of ICRISAT technologies that helped children succeed? A survey showed that if parents are more engaged in technology generation or implementation, their children are likely to fare better at raising and caring for trees. Students who used fertilizers or pesticides tended to be more successful on average than those who didn't. There was no correlation between household income and success in caring for trees. The Farmers for the Future program is only 2 years old; it is much too early to analyze its impacts. However, it appears that the program is creating motivation and enthusiasm for agriculture among the children and a spirit of entrepreneurship that was not there before.

Our major projects

Project name	Funding agency	Amount (US$)	Period
Enhancing groundnut productivity and production in drought-prone areas of West and Central Africa	Bill and Melinda Gates Foundation	2,200,000	2007–2010
Assessing the dynamics of poverty and land degradation in the Sahelian countries of West Africa	IDRC	600,000	2009–2011
Mobilizing regional diversity for creating new potential for pearl millet and sorghum farmers in West and Central Africa	BMZ/GTZ	1,150 000	2006–2009
Farmer-participatory improvement of sorghum and pearl millet genetic resources for increased adaptation to diverse production environments in West Africa	McKnight Foundation	580,000	2006–2010
Creating opportunities for poor farmers: Intensification of sorghum and millet systems using local biodiversity and market opportunities in semi-arid West Africa	IFAD	1,200,000	2006–2009
Sustainable seed supply: Farmer-managed seed marketing initiatives for sorghum and pearl millet in Mali and Burkina Faso and Niger	McKnight Foundation	420,000	2006–2010
Project on enhancing rainwater and nutrient use efficiency for improved crop productivity, farm income, and rural livelihoods in the Volta Basin	CPWF	1,500,000	2004–2009
Micro-dosing project	AGRA	1,300,000	2009–2010
TOTAL		**8,950,000**	**2004–2011**

For a complete list of our scientific publications please go to www.icrisat.org.

The EPMR was very successful for ICRISAT. The report stated: "ICRISAT today is a thriving research institute with a unique capacity to address poverty alleviation, food security, and natural resource protection in the SAT."

Sharing our successes: Station visits and activities

In 2008 ICRISAT hosted a wide range of events and welcomed several VIPs, from ministers to United Nations representatives, at Sadoré station in Niger and Samanko station in Mali. Here are some examples:

ICRISAT-WCA receives EPRM panel

ICRISAT–Niamey received two External Program and Management Review panel members: Drs Antonio Juan Hall from Argentina and Eric Yirenkyi Danquah from Ghana. They were at Niamey from 29 September to 1 October to visit some of ICRISAT's major partners in Niger, such as the National Institute for Agronomic Research (INRAN) and have a close look at the accomplishments of scientists and management at the regional hub. After 3 days they headed to ICRISAT's Samanko station in Mali. The evaluation took place in a pleasant atmosphere of professionalism. The panelists appreciated the "high quality of research" and facilities in place. Dr Danquah showed great interest in the genebank, admitting that genetics was close to his heart. For Dr Hall, the visit was also a unique experience as it was his first time in Africa.

From L to R: EPMR panel member, Dr Antonio Hall, with ICRISAT WCA Director, Dr Farid Waliyar, and Principal Scientist Dr Olanrewaju Smith

Open Field Days in Niger and Mali

For the third time, ICRISAT–Niamey organized an Open Field Day together with INRAN at Sadoré station on 8 October. Almost 250 participants attended, many even coming in from remote areas. The event's slogan 'INRAN and ICRISAT – Joint forces to improve rural community livelihoods' captured our objective, which was to provide information about our research, demonstrate the most promising technologies developed, and stress the strong collaboration between the two institutions. The enthusiastic and high level of participation showed once again how important it is to stay in close contact with farmers. The response of the media was also quite strong, with audiovisual and print media covering the open Field Day nationwide.

At ICRISAT-Bamako, a group of 10 farmers representing three villages currently engaged in the production of hybrid sorghum seed visited the hybrid seed production plots at Samanko on 9 October. The field visit and ensuing discussions addressed a range of management practices that can be employed to maximize the yield and quality of hybrid seed. This training visit reinforced and extended the experiences of these farmers who initiated hybrid seed production this year with help of the Institut d'Economie Rural and ICRISAT. It was also highly appreciated by representatives of an emerging private seed company who plan to undertake hybrid production with attending farmers.

Crop tour at Open Field Day, Sadoré station

World Food Day celebrated at ICRISAT-Niamey

ICRISAT hosted over 350 participants, as well as the national and West African media, at the celebration of the World Food Day on 16 October. The event was held following an invitation by the Food and Agriculture Organization of the United Nations and the Nigerian Government. Among visitors were representatives of national governments and United Nations bodies, as well as several ambassadors. Under the motto 'Global world security: The challenges of climatic change and bioenergy' scientists presented projects directly linked to climate change. Discussions during the conference that followed focused on *Jatropha* sp. research and other alternatives for energy generation, as well as climate change prediction.

ICRISAT celebrates Annual Day in Niger and Mali

Despite the warning that a lioness was roaming around with her cub, ICRISAT-Sadoré staff members were courageous enough to participate in the Annual Day celebration at the camping site of 'Game Park W' on 15 December. After the award ceremony for long-serving staff members and the handing over of germplasm certificates, Regional Director Dr Farid Waliyar invited everyone to have a relaxed day. Some had already arrived the day before, staying the night in tents. Sports were the major credo of the day, with the main highlights being a stinging 2:1 defeat of the 'ICRISAT All-Star Dream Team' by the 'International Forces' in a volleyball tournament, plus soccer competitions and 'pétanque', the French game of 'boules'. The entire venue was covered with groups of people engaged in lively discussion and laughing. They took a short break from their exertions at lunch time, enjoying chicken and mutton, fish, and couscous.

Ministers visit Sadoré station

Following an invitation by Regional Director Dr Farid Waliyar, the Minister of Agricultural Development of Niger, Mr Mahamane Moussa, and the Minister of Foreign Affairs, Mrs Aichatou Mindaoudou, paid a three-hour visit to Sadoré station on 10 October. They showed great interest in the research and facilities at the site. In the presence of the media they stressed the importance of ICRISAT in the region and praised its collaboration with INRAN.

EC delegation at Sadoré station

The head of the delegation of the European Commission in Niger, Dr Hans-Peter Schadek, visited ICRISAT-Niamey on 26 November. He was accompanied by some of his technical experts. As an agro-economist, many of his questions focused on productivity and the commercialization of ICRISAT's technologies. He appreciated that ICRISAT combines research with training of farmers, an approach he considered as essential for rural development in Niger. In fact he called ICRISAT's innovations a "hope for the region". He and Dr Farid Waliyar agreed that there is great potential for further cooperation in Niger.

Sports Day at Sadoré

The first Sports Day at ICRISAT's Sadoré station held on 27 February proved that science is a top-class sport. Let's take one of the four ICRISAT soccer teams for instance. They impressed with their professional sport dress and warm-ups, but in the end they lost the final. This was simply because the less-organized opponent (dressed in old T-shirts and trousers) adapted better to the sandy soil! The Sports Day was completed by volleyball matches, pétanque and, last but not least, the walking competition. When the mass of staff members started from the building to the main entrance and back, it looked like the New York marathon – nothing less!

The French Ambassador also visited ICRISAT's Sadoré station

Who we are

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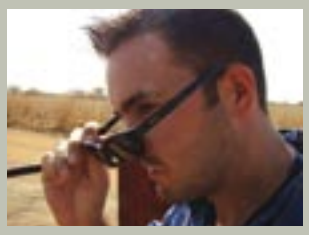

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