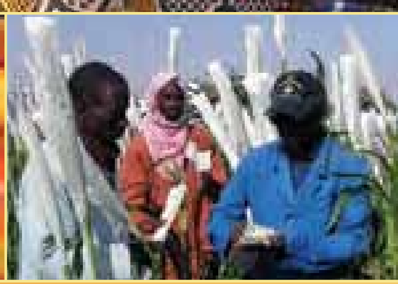
ICRISAT West and Central Africa 2009

Protecting Biodiversity, Providing Options




ICRISAT
Science with a human face

International Crops Research Institute
for the Semi-Arid Tropics

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that conducts innovative agricultural research and capacity building for sustainable development with a wide array of partners across the globe. ICRISAT's mission is to help to empower 644 million resource-poor farmers 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

If you ask me what my personal "word of the year" is for 2009, I would have to name two, without hesitation: *change* and *biodiversity*.

Change: because in parallel with the Consultative Group on International Agricultural Research (CGIAR), which has introduced reforms to enhance its effectiveness and efficiency to mobilize science for the benefit of the rural poor, ICRISAT is also undergoing significant changes. We are currently mapping out our new strategic plan to 2020, and while it won't be finalized until the end of 2010, we are certain that the West and Central African (WCA) region will play a major role in ICRISAT's future. We have already empowered the regional hub with more resources than ever and will continue to do so. In addition, the scientific and administrative collaboration between ICRISAT–WCA, its counterpart in Eastern and Southern Africa, and the headquarters in India has been strengthened. And the process of fortifying existing partnerships and forging new ones with the national agricultural research systems (NARS) and other organizations is ongoing.

Biodiversity: because after more than three decades, ICRISAT's focus on five mandate crops – sorghum, pearl millet, chickpea, pigeonpea, and groundnut – has been complemented by a more holistic approach, integrating the use and preservation of biodiversity. This means conserving genetic resources, diversifying mandate crops, developing farmer-friendly pest management strategies, and intensifying crop diversification, among others. The red flags are there for us to see: no longer can we ignore issues relating to biodiversity and the sustainable use of resources originating from nature.

In fact, ICRISAT is the custodian of more than 119,000 germplasm accessions of its mandate crops, from 144 countries. It also conserves duplicate samples at the Svalbard Global Seed Vault in Norway.

ICRISAT–WCA has been very successful in this direction. Jointly with the World Vegetable Center (AVRDC) Director General Dyno Keatinge, I received the CGIAR "Science Award for Outstanding Partnership" at the Global Conference on Agricultural Research for Development (GCARD) on behalf of ICRISAT at Montpellier, France. This award acknowledges our joint efforts at improving the lives of women and children in West Africa through vegetable breeding and promotion. This prize is both an honor and an incentive to continue our partnership-oriented approach.

Change through diversity: delivering scientific backup to bridge the gap between human needs and demands on one side, and natural resources on the other, is our response.

We are thankful to our donors, partners, and the Governing Board for their ongoing support in fulfilling our mission to reduce poverty, enhance food and nutritional security, and protect the environment of the semi-arid tropics. With regard to biodiversity, an ICRISAT scientist translated this mission into very simple but accurate words: "offering diversity to the diversity of farmers".

In this light, I am sure you will enjoy reading this report, which elucidates ICRISAT's main achievements related to biodiversity in the semi-arid tropics of West and Central Africa in 2009.

William D. Dar
Director General

Message from the Director West and Central Africa

The semi-arid tropics of West and Central Africa are rich in biological diversity, potential availability of crops and varieties, and options for securing food supplies and increasing farmers' incomes. The underlying question is: How do we bring these options to life?

ICRISAT is guided by the simple principle that farmers who have more choices in selecting their crops and varieties are better adapted to seasonal weather variations and are less prone to harvest failure. Farmers in the WCA semi-arid tropics are particularly vulnerable to the caprices of weather – and this is exacerbated further by the effects of climate change.

Biodiversity is an important resource which farmers use to adapt to these changes. We aim to understand biodiversity by studying and exploiting phenotypic diversity, intra-varietal diversity, and geographic differentiation. We focus on improving farmer-preferred and market-oriented cultivars of pearl millet as well as exploiting the diversity of sorghum and groundnut varieties. Our approach to crop and system diversification offers more alternatives to farmers, combining research on vegetables with water management and agronomy.

Biodiversity is the basis of the agricultural food chain. Linking farmers to markets is central to our work and is managed by our regional Seeds Project under the West Africa Seed Alliance (WASA). Our main task is to give small-scale farmers the seeds and technologies they need to be a successful part of the market chain.

As outlined in last year's Annual Report, our researchers work on the economics of diversification and its sustainability. This report highlights studies on the adaptation of pearl millet and sorghum in northern Nigeria and the role of soil and land management in mitigating climate variability. Socioeconomic studies help us to evaluate the true impact of our work and to identify appropriate technologies. Still, we must remember that farmers may not necessarily adopt new varieties, for cultural or other reasons.

Taking a participatory approach ensures the highest rate of adoption possible. Last year we trained research partners and farmers in statistics, multiplication and storage of vegetable seeds, breeding techniques, and seed enterprise management. To address the continuing loss of biodiversity in a changing climate, we conserve plant genetic resources in our regional gene bank in Niger for present and future use. We aim to develop the gene bank into a regional plant genetic resource conservation center for Sahelian crop species.

Without the region-wide collaboration of national agricultural research systems (NARS), CGIAR centers, CGIAR affiliates, regional organizations, farmers' organizations, and individual farmers, we could never reach our goals. We are also grateful to donors for their continuing support in fostering and intensifying impact-oriented research in the region.

Farid Waliyar
Director, ICRISAT West and Central Africa

Biodiversity: Understanding what it means to farmers

Agricultural production in the West African semi-arid tropics is influenced by the emergence of new markets, population growth, weather variability, and threats from climate change. We focus on approaches that improve yield and increase resilience to external influences, while also representing a low risk for farmers as the providers for their families. Diversification is a key method, as greater diversity in an agro-ecosystem means less risk of failure in the production system as a whole. But do we really understand the conditions under which biodiversity can be profitable for farmers? How can we increase biodiversity at the farm level? In order to find these answers, ICRISAT–WCA opted for a strategic research approach at both the zonal and village levels.

Zonal level

To assess regional variability, we measured the number and variety of species across different agro-ecological zones (northern and southern Sahel, central Sudan, and northern Guinea). This research indicates that the present level of diversity depends on the climatic gradient of increasing rainfall and length of growing season and decreasing average temperatures.

Biodiversity increases from north to south, as does the diversity of agricultural choices, as shown by the number of potential 'hunger crops'. These are plants that can be consumed during the vegetation period, when reserves are getting scarce and traditional staple crops are not yet ready for harvest. There are fewer hunger crops grown in the Sahel than in the Sudanese and northern Guinea sites. At the southern Sahelian site, only cowpea, early maize, fonio (*Digitaria exilis*), and gombo are mentioned by farmers, while at the northern Guinea site cowpea, groundnut, 'early' bambara nut, gombo, manioc leaves, and tubers, millet, blackberry, and mangoes are grown (Table 1).

ICRISAT scientist and farmers discuss the performance and quality of different pearl millet varieties (Tahoua region, Niger)

Village level

Plant diversity is correlated to distance from settlements. This is true for agricultural crops as well as non-domesticated, but useful, tree species. For example, stands of *Faidherbia albida*, or winter thorn, dominate close to settlements in northern Sahelian sites, as the indigenous deciduous tree thrives on frequently disturbed soil surfaces. And the cash crop groundnut is usually grown close to the settlement, where use of animal manure improves soil fertility.

Gender also plays an important role. Women prefer legume crops to generate cash and use minor crops such as hibiscus and okra to supplement their families' diets.

Soil conditions and local knowledge influence cropping decisions. More pressure on land resources and a long history of land use have produced sound local knowledge on which development initiatives can be built. Most farmers' fields do not include a variety of soil types, and they are forced to produce what they need on the available land. Their decision-making process is not necessarily linked to knowledge of soil variability. Monthly surveys of plant products in local primary markets might

Table 1. Identified hunger crops at project sites on an agro-climatic gradient in West Africa

Niger (northern Sahel)	Mali (central Sahel)	Burkina Faso (central Sudan)	Ghana (northern Guinea)
okra cowpea hibiscus leaves cassia tora very early maize (disappearing)	okra cowpea fonio early maize	okra cowpea groundnut bambara nut aubergine early maize early sorghum	okra cowpea groundnut 'early' bambara nut* manioc leaves and tubers blackberry mango early millet

* This bambara nut variety is 'early' in relation to other crops according to farmers' observations, not in a genetic sense.

give us an indication of the influence of local markets on farmers' decision-making. Data gathered so far do not deliver a clear picture and need further evaluation.

The action research component within this project tries to increase village and farm level phyto-diversity by actively promoting crops, varieties, and management options. In order to increase impact, all activities are carried out on-farm in a participatory manner. From year to year the number of available options has been reduced, but the area cropped with new species or varieties has increased. The process of introducing new varieties follows a pattern. Researchers play a greater role in the first year, when farmers have little or no knowledge of new varieties; their influence recedes by the end of the third year as farmers become fully trained in seed multiplication and take over its management (Fig. 1).

ICRISAT draws the following preliminary conclusions from its combined zonal and village level approach:

- The most impact with respect to species diversity can be achieved by investing in off-season activities, predominantly in garden crops under irrigation that have a good chance of addressing new and existing markets.
- Adaptation potential for a new (particularly staple crop) variety depends on site-specific conditions. For example, if farmers speak about early varieties, they mean those that came before the variety they have in their possession, not in the absolute sense of the genetic variation in a gene bank.
- Taste and conservation behavior play an important role in the adaptation of a variety, and these aspects are often gender-specific (i.e. threshing and grinding).
- Farmers need to learn basic breeding and selection strategies, especially for open-pollinating crops such as pearl millet, which tend to cross with local varieties.
- Working with farmers' organizations has proven to be efficient, but knowledge can only be shared with members. Other means need to be developed to reach more farmers, such as community radio.

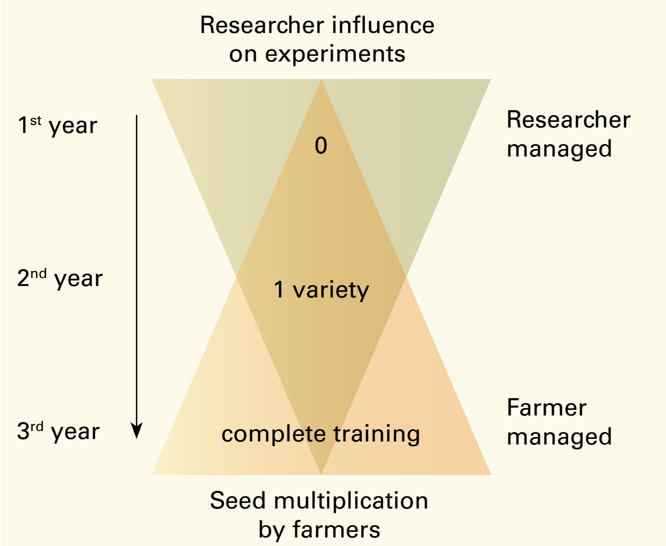


Figure 1. The process of introducing new varieties and training farmers in seed production

It is clear that the biodiversity approach offers many opportunities, especially for smallholder and subsistence farmers. But it does not solve all of the challenges they face, especially those imposed by external economic forces. So far, the factors behind the use of existing biodiversity are not yet fully understood. There is a need for further research at the local level.

What farmers know about climate change – and how they mitigate its effects

Climate change affects biodiversity and hence people's lives, especially in rural areas where households are heavily dependent on rain-fed agriculture and natural resources. Understanding farmers' perception is essential in designing appropriate coping and adaptation strategies. Focus group discussions in eight villages in the Tahoua region in Niger and in four villages in Sokoto state in Nigeria assessed farmers' perception of changes during the last 30 years and the adaptation strategies they used.

Farmers displayed a high level of knowledge and awareness of climate change and how it affects their livelihoods. The major climate change indicators that they reported included increased temperatures, delayed onset of rains, and insufficient levels of rainfall. They saw the major consequences of climate change as: lower yields, drop in ground water levels, loss of biodiversity, reduced soil fertility, increased wind and water erosion, decreased quantity of rainfall, and poor rainfall distribution. These are all consistent with the prediction of reduced and erratic rainfall in semi-arid areas. Other consequences included flooding, abrupt ending of the rainy season, decreased area of grazing land and higher incidence of hot winds, and changes in surface water quantities such as drying of rivers, ponds, or wells. In some villages, temporary migration patterns became permanent.

Villages reported major changes in the socioeconomic environment and livelihoods. Migration

Farmers are aware of climate change and have developed sophisticated strategies to adapt to it

Women in their vegetable garden (Tahoua region, Niger)

was reported as a major strategy to cope with climate change, followed by consumption of non-traditional foods. In half of the villages surveyed, farmers are earning income by working for other farmers and are more engaged in vegetable production where water is available. Fattening of livestock and petty trade have significantly grown. Women are increasingly involved in cereal production – a new phenomenon in Muslim West African societies, where customarily only the men farm pearl millet and sorghum crops. Women are also involved in selling wood, groundnut oil processing and trade, and livestock fattening, and are earning income threshing pearl millet for other farmers. These trends clearly point towards a feminization of agriculture due to climate change. Due to the reduction of grazing area, households are intensifying livestock rearing and there is a market for crop residues, which are stored and sold. Most villages have seen a significant rise in the ratio of small to large ruminants.

Responses to climate change and other biophysical and socioeconomic changes are related in a complex way. Farmers reported a wide range of adaptation strategies, including introducing new crop varieties or crop management options. For example, they adopted early maturing varieties in response to reduced crop cycles, used more manure, increased the area cultivated to anticipate potential early rains, and adopted soil and water management options such as *zaï* holes.

The study also revealed that villages affiliated with projects that promote soil and land management practices and with better access to markets use adaptive technologies more often than others. Farmers have adopted or enhanced their use of mulching, manure, and tree planting and have introduced new drought-tolerant varieties. But this shift to agriculture has actually increased the villagers' vulnerability to the effects of climate change, since crop production in the area is riskier than traditional pastoral livelihoods.

Farmers were well aware of the importance of irrigation as an adaptation strategy. Vegetable gardening is a major coping strategy. In some cases the government has invested in large irrigation perimeters, making sufficient water available for crops. In other cases there are large ponds from which farmers draw water for irrigation; they also dig wells for watering vegetables. Irrigation has proven to be an effective adaptation strategy, with fewer farmers migrating to follow water sources.

Improved crop varieties are good tools for adaptation to climate change. Almost all villages adopted early-maturing drought-tolerant crop varieties. Governments, research institutes, and development planners have invested in the development of these varieties. However, poor seed delivery schemes have limited access to uptake of these varieties, despite more than US$45 million invested in building up seed systems in Niger. There are plans to redesign such schemes and focus on those that are institutionally more sustainable.

Ensuring diversity in our mandate crops

Pearl millet: Understanding and promoting its diversity

Pearl millet [*Pennisetum glaucum* (L.) R. Br.] is a highly stress-tolerant staple cereal grain of the hottest, driest regions of sub-Saharan Africa and South Asia. West and Central Africa (WCA) is the primary centre of origin and diversity for pearl millet. The photo below illustrates the tremendous diversity of local pearl millet landraces in WCA. It also shows the diversity of farmer preferences, highlighting the fact that a 'one size fits all' approach does not work in WCA.

Genetic diversity is the mainstay of breeding programs. The ICRISAT–WCA pearl millet improvement program – together with its national agricultural research systems (NARS) partners in Burkina Faso, Mali, Niger, Nigeria, and Senegal – aims to find a better understanding and use of pearl millet diversity from WCA in the development of improved, farmer-preferred cultivars for this region. Therefore, we study and exploit diversity at different levels.

Understanding diversity and promoting exchange

We characterized 424 pearl millet landraces from all over WCA in Burkina Faso, Mali, Niger, Nigeria, and Senegal. These landraces exhibited wide ranges for all assessed morphological, agronomic, and resistance traits. From these characterization trials, each participating country identified promising landraces for breeding, as well as morphologically contrasting germplasm groups for crossing. As a result, we identified the diversification of breeding materials in each partner country.

Linking phenotypic – physical, as opposed to genetic – observations to the geographic origin of the pearl millet landraces revealed certain patterns of geographic differentiation. Flowering time was correlated to latitude, reflecting a higher frequency of early flowering accessions in the north and later flowering accessions in the south. This corresponded to the rainfall patterns in the region. But this correlation is not universal, as two types of pearl millets are usually grown in the wetter south – early millets to cover the 'hungry period' and late-maturing ones for higher productivity. Geographic differentiation for panicle length revealed two main groups:

1. Longer panicle accessions originating from north-eastern Benin, northern Burkina Faso, western Niger, and Senegal
2. Shorter panicle accessions originating from western Benin, southern Burkina Faso, Cameroon, Central African Republic, Mali, and eastern Niger.

Enhancing heterozygosity (intra-genotypic diversity)

Being highly outcrossing, pearl millet is naturally highly heterozygous. It needs to have two different alleles of most genes to perform well. Genetically distinct groups of WCA pearl millet landraces, referred to as heterotic groups, produce superior hybrids when crossed. Heterotic groups were initially identified by diversity

Diversity of panicle traits in West African pearl millets

A farmer indicates his preferred pearl millet panicle type (Dioula, Mali)

assessment based on agro-morphological variation and genetic diversity at the DNA level. They were then validated through multi-location evaluation of crosses. This enabled identification of the optimal genetic distance between parental materials that is required to maximize hybrid vigor and therefore agronomic performance.

In pearl millet, the detection and use of heterotic groups provides a basis for sustainable breeding of open-pollinated as well as hybrid cultivars, as they both profit from intra-genotypic diversity and hybrid vigor. The first fruit of identification of these heterotic groups is a cross of genetically distinct landraces from Niger and Senegal, "Tiouma x Souna" that exhibits outstanding performance and high farmer-preference indices in on-station and on-farm trials in Niger.

Studying intra-varietal diversity as mechanism of adaptation

Local landraces of pearl millet are highly heterogeneous. Data gained from full-sib selection trials confirmed that pearl millet landraces from Niger contain significant genetic variability, such as for flowering time. Differences between the earliest and the latest full-sib families derived from the same landrace were 16 days at minimum in the Bondabia landrace and 39 days at maximum in Bazagome. Such intra-varietal diversity for adaptation traits can reduce the vulnerability of the landrace and therefore enhance its yield stability. For example, during a dry spell not all plants will be affected during their most sensitive stage, so some will survive better. This 'populational buffering' mechanism against environmental variability has evolved during thousands of years of natural and human selection; it must confer some advantage for survival, grain yield performance, and stability. Therefore, plant breeders must be concerned with how much genetic heterogeneity is desirable or necessary to obtain improved varieties that are able to out-yield local cultivars under extreme and variable growing conditions such as those existing in the Sahel.

Offering diversity to the diversity of farmers and farming conditions

Growing conditions and farmer preferences in WCA are highly diverse. Therefore ICRISAT–WCA works together with partner NARS to develop efficient participatory population improvement methodologies. The aim is to "offer diversity to the diversity of farmers". The approach includes community management of diversified pearl millet populations and training for women and men in the selection of target traits according to their specific production objectives. This participatory breeding research contributes to development of farmer-preferred cultivars and the maintenance of genetic diversity in farmers' fields. It even helps to develop concepts for *in-situ* conservation of crop genetic resources.

Lessons from the pearl millet stem borer

The agro-ecological approach to agro-ecosystem management relies on two pillars: vegetational diversification and soil biological activity enhancement. Some crop combinations or crop residue management techniques reduce erosion and increase soil biological diversity and activity, resulting in enhanced soil fertility. This then bolsters food security. But although one would expect that crop management options based on these principles should lead to agro-ecosystems that are more resilient to crop pests, this is not always the case.

In earlier studies conducted by ICRISAT in Niger, borders of the perennial grass *Andropogon gayanus* were shown to efficiently protect millet against violent winds. This grass was also found to be an alternate host of several cereal stem borers in Africa, including the millet stem borer *Coniesta ignefusalis*, a major pest across Sahelian countries. The idea was therefore raised to use Andropogon grass as a 'trap crop' for stem borer management.

ICRISAT also reviewed the benefits and drawbacks of measures taken by farmers to reduce wind erosion, such as mulching and leaving millet straw in fields after the harvest to protect soil, since it was found that the most critical period for wind erosion was at the shift from dry season to rainy season (April to June).

Researchers conducted a trial to assess the impact of millet (cv. ICMV IS 99001) crop residues management on the incidence of insect pests in 2008 and 2009. Four different treatments were tested: three involved millet stems cut and placed on the fields respectively at harvest and every second month thereafter (namely at the beginning, in the middle, and at the end of the dry season), and a fourth with stems left upright until the onset of the rains. During the 2008 and 2009 millet harvests, samples of millet stems taken in each plot were compared to samples taken along an Andropogon grass hedge bordering the trial area. In each stem, the numbers of stem borer holes and stem borer larvae were recorded.

Andropogon grass was clearly ruled out as a potential trap crop for Coniesta. Bored stem incidence in Andropogon hedge bordering millet plots was significantly lower than on millet and involved species other than *C. ignefusalis*. It was also found that treatment with millet stems cut at the end of the dry season, supposedly the most effective treatment against wind erosion, was also the most favourable to Coniesta carry-over. This clearly stresses the importance of documenting the impact of agro-ecological management options on all factors likely to influence crop yields in the long run, including soil erosion, fertility, and pest damage, so as to adapt technical solutions to the abiotic and biotic environments.

Sorghum: Enhancing local diversity for the market

A series of participatory research and variety tests in collaboration with the *Institut de l'Environnement et de Recherches Agricoles* (INERA), the *Union de Groupement*

Pearl millet stem borer larvae in stem residues at the end of the dry season

pour la Commercialisation des Produits Agricole (UGCPA), and the *Centre de Coopération Internationale en Recherche Agronomique pour le Développement* (CIRAD) was conducted during 2002 and 2005 in the Boucle du Mouhoun region in Burkina Faso. As a result, four landraces with relative short maturity time were found to be most in demand by farmers. These varieties were either old landraces preserved in an INERA gene collection in Saria (*Centre de Recherche Régional du Centre*) or those collected recently in other regions of Burkina Faso. Breeders continued to purify these landraces. In 2006, in a new collaboration with the ICRISAT breeding program in Mali, UGCPA and INERA started to develop an approach for wider diffusion.

UGCPA requested and received from the Saria research station breeder seed of four purified landraces (Kapelga, Gnossiconi, Flagnon, and Raogo), one improved red-grained caudatum line (IRAT 9), as well as training in the production of certified seed. The production and commercialization of the seed was organized by UGCPA itself. Seed production in the following years increased substantially, to the benefit of the farmers' organization and the seed producers. The most preferred varieties were Gnossiconi and Kapelga. Further options to satisfy the increasing demand for certified seed of the preferred varieties were discussed. Researchers and seed producers agreed that UGCPA should be involved in the production of foundation seeds, to overcome the limiting isolation requirements faced by the research station, since at least 200 m are needed between fields of different varieties on-station. Farmer organization representatives and agents of the National Seed Service sat together to discuss a strategy for better access and reduced limited transportation needs for the field controls in the certification process. One solution was to locate seed production plots on the same axis. This collaboration also allowed for continued information exchange about new varieties between farmers, the extension service, and the researchers.

Through the seed production initiatives, several varieties were not only introduced but also diffused in a region where the cotton maize system tends to compete with sorghum (Table 2). Since these were mainly local varieties purified by breeders, these initiatives contribute to the enhancement of local sorghum biodiversity. Thanks to these distinct traits farmers had more options, such as improving local strategies by growing early-maturing varieties to face the changing rainfall patterns they observed. While using existing germplasm collections as a source of diversity, the value of the Saria collection was directly experienced, as varieties once lost to farmers were brought back to use.

Taking a biodiversity-friendly approach: One farmer's account

Mr Bonzi Nonyeza is 40 years old and lives with his wife and seven children in Kossi village in Burkina Faso. He is a farmer and president of the local committee for cereal service at UGCPA. Since 2006, ICRISAT and INERA have collaborated with him on participatory breeding, diffusion, production, and commercialization of sorghum. He tells of how his village benefits from the biodiversification approach:

"The big news from last year is the fact that the varieties selected in a participatory way by the project's farmers have now gained national attention. Producers in Dédougou have given a portion of their seeds to INERA in Ouagadougou. This drew a lot of interest from scientists and farmers, who received the seeds from the state. They were mainly disadvantaged farmers, so the varieties have proven to be effective even in hard conditions.

The national union of seed producers of Burkina Faso (*Union Nationale de Producteurs de Semences du Burkina Faso*, UNPSB) had already asked UGCPA for Gnossiconi and Kapelga for the 2009–2010 growing season. So, these seeds produced by UGCPA were recommended and used as base varieties in the following season, even on a national scale.

In this way, farmers involved in the project will see the fruits of their labor benefitting a large number of producers indirectly. This will also increase national production and help fight poverty by ensuring food security for families in the villages where the seeds are planted. The project will also boost the amount of seeds produced commercially by UGCPA. The Union's action plan now includes an emphasis on the production and consumption of these varieties."

Table 2. Farmer criteria and agronomic data from on-farm trials for four preferred sorghum varieties

Sorghum variety	Farmer preferences	Total grain weight (g)	Grain yield (kg/ha*)
Raogo	Earliness, large grain size, good grain quality for *tô* preparation, high flour yield (large, vitreous grains), good beer quality	22.8	2171
Flagnon	Earliness, productivity, superior grain quality for *tô* preparation (white colour and hardness), stems are fresh and good for fodder	22.1	2142
Gnossiconi	High productivity, earliness, supposed resistant to Striga, good threshing abilities, grain quality good for *tô* and beer production	23.3	2115
Kapelga	Earliness, productivity, good grain quality (hardness, white colour large size), resistant to breakage	21.0	1851

* Based on four sites with two repetitions per site and small plot size (12.8 m^2/entry)

Linking farmers to markets: The 'career path' of Soumalemba

The Seeds Project marked 2009 as its second year. It was a year of expansion, with a number of activities that support the West Africa Seed Alliance (WASA) in establishing a sustainable commercial seed industry in the subregion. Within this endeavor, the support of existing companies and of those who intend to found new ones is crucial. It goes along with improving the kind of environment that will facilitate seed trade through national surveys and consultation with those companies, input distributors, and other stakeholders at the national and regional level. The Seeds Project tries to get everyone into one market. The sorghum variety Soumalemba is an example of one product that has hit full speed on West Africa's new market highway.

Certified Soumalemba seed stored at the seed company "Comptoir 2000" (Sikasso, Mali)

Before the Seeds Project arrived, the Sikasso region of Mali was a blank slate in terms of sorghum testing. The Project introduced tests kits of eight improved and two local sorghum varieties to farmers' groups and individuals in six locations. The farmers were to choose their preferred varieties, which the Seeds Project would promote later. The majority of the farmers selected the sorghum variety Soumalemba (IS 15401, a Guinea-caudatum type) as their first choice because of its big white grain, good yield, and good tolerance to the weed Striga. Harvest data collected showed indeed that Soumalemba had the best grain yield.

Surprisingly, the head of the sorghum program of Mali's national agro-economy institute (*Institut d'economie rurale*, IER) informed the Seeds Project that Soumalemba was registered in the national catalogue in 2002 as adapted to the southern zone of the country. So we conducted a rapid survey during the following dry season to identify high-quality certified seeds in the major sorghum-growing areas of southern Mali. The Farmer Cooperative Seed Association (COPROSEM) of Siby was identified as having more than 2 t of high-quality certified Soumalemba seeds. COPROSEM was then linked with two seed companies and two agro-dealers from Sikasso, who sourced over 1.5 t of Soumalemba for distribution in Bamako and the region of Sikasso. The seeds were reconditioned in different packaging materials and displayed in their respective shops.

Soumalemba also made its mark at the World Food Program initiative Purchase for Progress in Mali, which targeted smallholder farmers, particularly women. The aim was to buy 1500 t of millet and sorghum. Producers in two villages greatly appreciated the variety Soumalemba and organized themselves to purchase enough certified Soumalemba seeds to cover 17 ha. The Seeds Project scientists will follow the path of Soumalemba into the West African market chain.

Low phosphorus in soil – a women farmers' burden

Soil-phosphorus deficiency is a major factor in reducing sorghum and pearl millet growth and productivity across the full range of rainfall zones in West Africa. Insufficient phosphorus (P) leads to reduced root growth – and therefore smaller plants – and delayed flowering. This delayed development increases the risk of yield loss or failure.

On-station studies of over 100 West African sorghum varieties have been conducted in collaboration with IER in Mali over the past 4 years. These experiments show that varieties differ significantly for their ability to produce grain and to maintain stable development under low-P conditions. Furthermore, variety performance crossovers occur, and specific selection for adaptation to poor soils is needed.

Five varieties have been identified to have superior performance under low-P conditions in on-station studies (Table 3). To find out how these varieties perform across the range of soil-phosphorus conditions found in farmers' fields, we initiated a series of 12 on-farm trials in 2009. Preliminary results show that specific adaptation to low-P conditions is seen only in the most infertile soils.

Table 3. Sorghum varieties showing superior yield and adaptation to low soil phosphorus

Common name	Scientific name	Origin
Doua-G		Landrace from Mali
Soumalemba	IS 15401	Landrace from Cameroon
Tiandougou	98 SB-F4DT-78	Inter-racial breeding line from IER
Ngolofing	CSM 660	Landrace from Mali
NafalenP6	GPN01 S01 266-2-1	Population derivative

However, soil analyses from a total of 76 farmers' fields showed that the on-farm trials conducted in men's fields in 2009 did not actually represent the poorest soils. A total of 81 percent of women's field sampled in the Mande region and 14 percent in the Dioïla region had even lower P levels than the poorest men's fields. This suggests that the problem of low soil phosphorus is most severe for women.

The identification of differences among West African sorghum varieties for adaptation to low-P conditions is certainly a success. But more work is needed to make a significant impact. Confirmation of varietal superiorities under farmers' field conditions – especially in women's fields – must be continued. Also, integrating genetic and natural resource management is needed to obtain the benefits of both varietal adaptation and management practices that maintain or increase available phosphorus in the soil.

Mali's sweet sorghum for food and fuel

As in many other African countries, sweet sorghum is valued as a potential source of biofuel in Mali. Presently, ethanol is produced from sugar cane, mostly for the pharmaceutical and food-beverage industry. To develop a value chain model for ethanol production from sweet sorghum that is adapted to subsistence production

Transporting sweet sorghum harvest at the Samanko research station (Mali) for observation

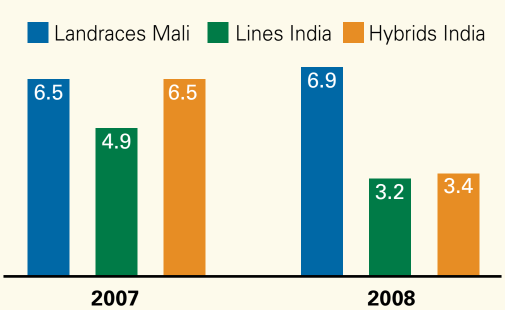


Figure 2. Dry stem yield without leaves of Malian sweet sorghum landraces, sweet sorghum hybrids, and sweet sorghum breeding lines from India conducted in 2007 and 2008 (t/ha)

systems, ICRISAT and IER conduct ongoing research on the production potential of grain-fuel sweet sorghum varieties in the Sudanian and North-sudanian zones. They also compared these varieties to inbred lines from India and Mali – as well as to hybrids and germplasm from Ethiopia – for sugar and grain yield.

In collaboration with CIRAD, ICRISAT and IER currently study more than 65 sweet sorghum landraces, varying greatly in a range of characteristics. In Mali, sweet sorghum varieties are harvested before grain maturity and their stems are used as a snack similar to sugar cane, either for family consumption or sold on the market.

Preliminary results of five different field trials at the Samanko station (Sudanian zone) showed an unfavorable distribution in 2008, as flooding and drought affected plant development.

A strong performance for sugar yield

Malian landraces proved to be high in both juice yield and sugar content and are highly competitive with the best performing sweet sorghum breeding lines from India. Landraces showed an average 2 percent higher sugar content compared to the hybrids. They gave the same yields under favorable conditions and out-yielded sweet sorghum breeding lines and hybrids under unfavorable conditions (Fig. 2).

Grain yield potential and grain quality

Grain yield of Malian landraces is low, with an average on-station yield of below 1 t/ha. The quality of the grain is also poor. Under favorable conditions, the hybrids out-yielded all the other cultivar groups by about 50 percent. Local women farmers agreed that the grain from landraces would not be preferred for *tô* (a traditional dish made from cereal flour accompanied by sauce) while the hybrids and breeding lines from India were considered suitable for porridge.

Towards a grain–sugar–fodder variety

Results from 2008 and 2009 showed that the trial mean for sugar content, stem yield, and grain yield of Ethiopian germplasms of the caudatum or durra-caudatum race surpassed all other cultivar groups. Even though grain quality does not reach those of the local Guinea type, farmers were impressed by their high fodder and grain yield potential. Together with IER, we now carry out crossing programs to create new diversity by building on the various advantages of the local and introduced cultivars. One of the main goals is to improve grain quality while maintaining high sugar content. The aim is to create several sweet sorghum ideotypes adapted to the diverse needs of rural communities. Examples are grain qualities for food or local beer production, as well as fodder production, different maturity durations, and agricultural production.

Diversity that harms: Controlling Striga

Striga hermonthica, a parasitic weed growing on dryland cereals, is a major constraint to cereal production. This beautiful but dangerous plant has a very high degree of morphologic and genetic diversity. This allows it to parasitize many different crop hosts such as sorghum and millet in areas with annual rainfall ranging from 350 mm to more than 1200 mm per year.

ICRISAT and the University of Georgia launched a project on the drivers of population density and genetic diversity of *S. hermonthica* in May 2009. Scientists looked for clues on how to guide breeding efforts and develop integrated management strategies against *S. hermonthica* and its devastating impact on cereal production. High population densities of up to 70,000 Striga seeds per square meter can cause yield losses of 40–100 percent in pearl millet and sorghum fields.

In 2008 and 2009, we sampled roughly 1600 individual plants from 40 populations from fields in Mali, Niger, and Senegal. These plants grew in different agro-ecologies and on different host crops such as sorghum, pearl millet, maize, and rain-fed rice. We determined their genetic diversity and analyzed soil samples to determine the Striga seed density for each population. Secondary environmental variables, such as Global Positioning System (GPS) location, host crop species and variety, soil parameters, and crop and fertilization histories were measured to help explain population differences in genetic diversity and seed bank density.

Preliminary results showed that of the total genetic diversity, about 85 percent is shared by all populations and only 15 percent is specific to one or more populations (Fig. 3). This is to be expected for an obligate out-crossing plant like *S. hermonthica*. In this way, *S. hermonthica* behaves more like pearl millet than like sorghum. But a number of major steps have to be taken in order to

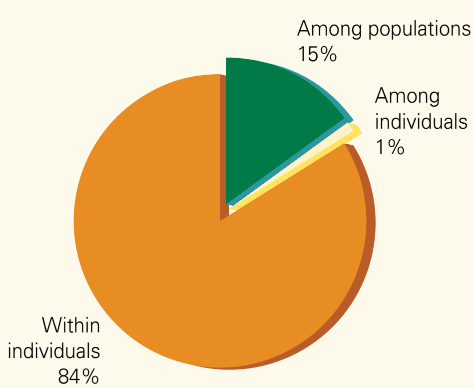


Figure 3. Genetic diversity within individual, among individuals, and among populations of *Striga hermonthica,* based on 2008 data

develop new control options and resistant varieties of sorghum and pearl millet:

- Determine whether genetic makeup and diversity of populations are affected by geographical location and host crop species on which the plants were collected.
- Identify relationships between seed bank density and secondary environmental variables such as location, host species, soil type, and cropping histories of fields.
- Translate the results into objectives and guidelines for the development of resistant varieties of sorghum and pearl millet as well as technologies and cultural practices for the control of *S. hermonthica*.

The research and results from this collaborative project will help us acquire a deep understanding of the ecological drivers of seed bank density and genetic diversity of *S. hermonthica*. With this information, we hope to stay one step ahead of this noxious weed when developing new control options and resistant varieties of sorghum and pearl millet.

ICRISAT scientist measuring the transpiration efficiency (TE) using the "dry down" method (Sadoré, Niger)

Groundnuts: Bridging the gap between potential and actual yields

In the semi-arid zones of West Africa, groundnut productivity is limited by a number of stresses, both abiotic (drought) and biotic (foliar diseases, groundnut rosette, and aflatoxin contamination). To improve productivity at the farm level and bridge the gap between potential and realized yield, there is a need for varieties that have traits preferred by farmers and demanded by markets. The major goal of ICRISAT's groundnut improvement program is to develop diversified and enhanced groundnut varieties for greater yield potential, nutritional quality, multiple disease resistance, and adaptation to the farming systems. Some highlights of the program include:

- Supplying 490 advanced breeding lines (short duration, medium maturity, tolerant to foliar diseases and rosette, fresh seed dormancy, and confectionary types) to collaborators in Benin, Cameroon, Chad, Ghana, Mali, Niger, and Togo. We expect to identify farmer- and market-preferred varieties for local production from this rich genetic base.
- Conducting a series of replicated preliminary and advanced trials to evaluate their agronomic performance and reaction to foliar diseases. Among the 417 lines tested, 187 lines with multiple attributes were selected for further testing.
- Conducting field and pot experiments involving 268 groundnut reference set accessions, which were phenotyped for drought-related traits such as yield, harvest index (HI), and transpiration efficiency (TE) under post-rainy season stress conditions. We grew a subset of 81 entries at two different planting times to simulate the end-of-season drought effect on yield and HI. The accessions revealed large variations in all three traits under both water stress and sufficient watering. We selected several accessions to generate new populations with enhanced drought-related traits.
- Screening 166 groundnut mini-core accessions from the 2008 trials in 2009 for tolerance to aflatoxin contamination, along with a reference set. The resistant lines identified in 2008 maintained their levels of resistance. A wide range of aflatoxin

levels was observed in the accession. Aflatoxin content ranged from very low (< 5 ppb) to over 1000 ppb. We identified accessions that were superior to the most highly resistant cultivar grown in semi-arid West Africa (55-437) in terms of aflatoxin levels. These add to the diversity of the aflatoxin-tolerant germplasm and will contribute significantly to the management of aflatoxin contamination in the region.

- Evaluating variety adoption and enhancing variety diversity in the cropping systems through Farmer Participatory Variety Selection (PVS). Among the new varieties selected by farmers, ICGV 86015 and ICGV 86124 yields were 25 to 40 percent higher than the traditional varieties in Mali. In Nigeria, ICIAR 19BT was the variety most preferred by farmers in Kano, Katsina, and Jigawa states. These varieties are candidates for formal release and will add diversity to the currently grown varieties in their respective countries.
- Producing 500 kg of nucleus seed of 39 varieties and 3 t of breeder seed of nine varieties included in the PVS trials at the Samanko research station, to ensure availability of breeder seed of released and pre-released varieties. These were made available to both private seed companies and individuals who want to produce foundation seed.
- Pinpointing drought-tolerant groundnut varieties. We assessed a collection of groundnuts in pots and in-field under drought conditions to find new sources of tolerance to water deficits and to identify genotypes that differed in terms of grain yield, HI, and TE. Some accessions demonstrated increased grain yield and/or HI under stress conditions and thus could serve as new sources of drought tolerance. But our results showed a wide variation in TE in the collection. Surprisingly, none of the farmer-preferred varieties were among the top performers.

Some of the different groundnut varieties commonly available in West Africa

Offering alternatives to farmers

Farmers know it when they 'sow' it: Trends in the adoption of modern varieties

During the last 20 years, ICRISAT has collaborated with the Institute for Agricultural Research (IAR), the Lake Chad Research Institute (LCRI), and agricultural development programs to invest in the development and dissemination of sorghum and pearl millet varieties in northern Nigeria. More than 10 varieties have been developed and are adapted to a wide range of agro-ecological zones. But it was unclear if they had been fully adopted.

Systematic data from 1136 households in 116 villages were collected by ICRISAT between December 2009 and January 2010. The collected data reflected farmers' knowledge of varieties – whether they were adopted or not, which varieties were grown from 2004 to 2008, the level of sorghum and pearl millet plots, and household assets. We also did a crucial qualitative evaluation of the farmers' perception of welfare changes following the adoption of improved varieties.

The survey results are clear: extensive exposure to modern pearl millet varieties – as in the case of SOSAT C88 – has led to high adoption rates. Likewise, lower exposures to sorghum varieties resulted in fewer farmers using them. In general, farmers were not very exposed to modern sorghum varieties and this was reflected in the relatively low adoption rate. But almost all who were exposed to modern varieties adopted them. The major constraint to adopting modern varieties was the lack of seeds. We found that some sorghum varieties (ICSV 400 and ICSV 111) face some technological problems, and more research may be needed to improve yield. Also, government support is crucial in implementing sustainable strategies for seed production and delivery to make varieties available to end-users.

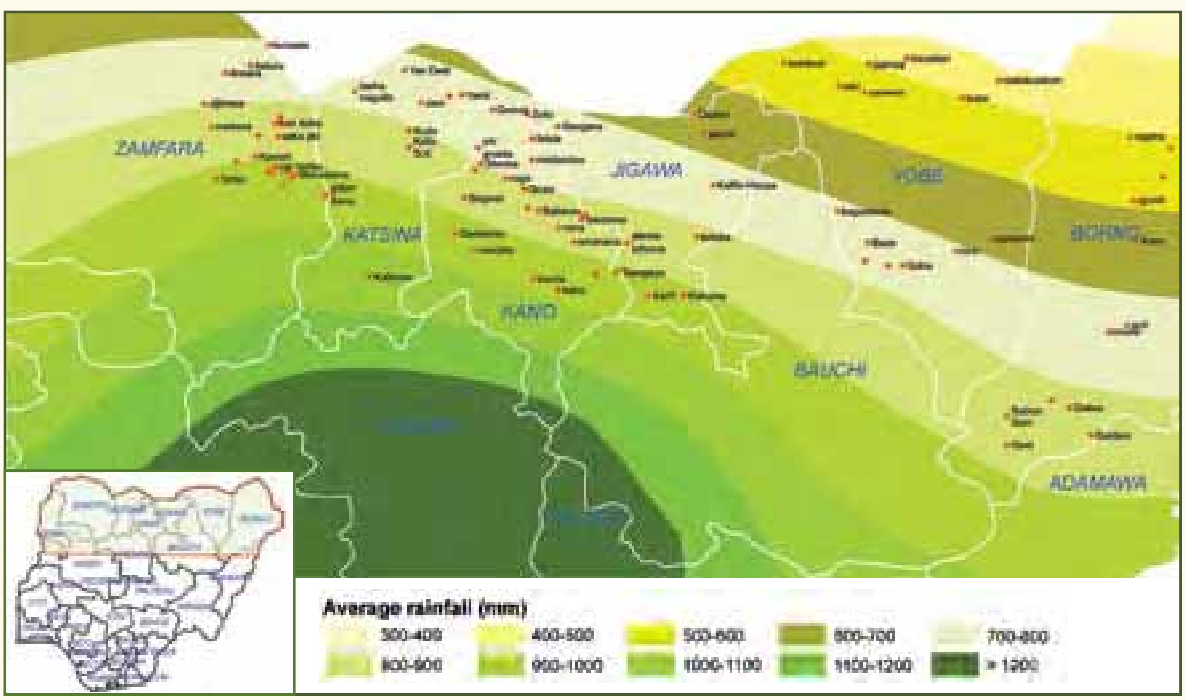


Figure 4. Modern sorghum and pearl millet varieties in northern Nigeria

Jatropha curcas: Really a biofuel wonder?

Jatropha curcas is one of the most attractive biofuel plants promoted in the semi-arid tropics of West Africa. Since the last oil crises, which lead to soaring fuel prices in 2006 and 2007, *J. curcas* has been widely planted in many countries in Asia and Africa, including thousands of hectares in Ghana, Mali, and Tanzania. Jatropha cultivation is spreading through investments by private companies and small-scale farmers. Although many companies began planting Jatropha for large-scale seed production in West Africa, it is widely recognized that these actions are not supported by strong scientific data on seed yield in the targeted production areas.

ICRISAT's main focus in Jatropha research is on two objectives: the identification of elite Jatropha material for seed production and the development of agronomic tools for Jatropha cultivation under semi-arid conditions. We analyzed seed production data from 2007 to 2009 to identify the best seed-yielding accessions among a total of 16 evaluated at ICRISAT's Sadoré station in Niger.

Pooled data showed significant differences between accessions (P=0.036). The best three accessions identified so far are among those from India, Guinea Bissau, and Mali, with average annual yield of a little more than 320 g per tree over three years. The lowest yield was given by Las pilas, a Mexican accession with an average annual yield of 64.8 g. The results also indicated wide variability in seed yields within accessions, which explains the weak variability between provenances. The quick decline in seed yield is probably due the poor growing conditions of the sandy soils in Niger, suggesting that Jatropha plantations will need appropriate soil fertility management measures.

The mean yield is less than 200 g in over half of the trees, and is higher than 500 g in only 15 percent of them. Only 4 percent of the trees are identified as elite plants with a mean annual yield superior to 1000 g (Fig. 5). Results from regression analysis indicate that production of individual trees of one year is correlated with the production of the same trees the following year.

These performances are far from the 3–5 kg yield reported by many authors as an acceptable basis for estimating Jatropha productivity. Even under irrigated conditions, yield is lower than 1.3 t/ha for 96 percent of the trees. The poor yield observed indicates that Jatropha growers might be disappointed if estimates of future production are done carefully using data collected from ecological zones and under agronomic conditions comparable to the production areas. There is a need to undertake Jatropha improvement research with the objective of developing varieties with better yield performance under semi-arid conditions.

ICRISAT is currently conducting a study on morphological and genetic variation, which will serve as a basis for Jatropha breeding under the ecological conditions of the semi-arid tropics of West Africa.

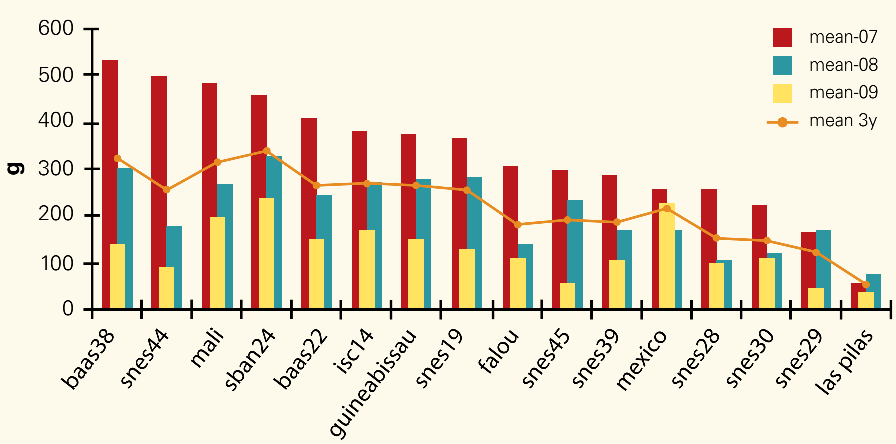


Figure 5. Yield performance of *Jatropha curcas* accessions over 3 years

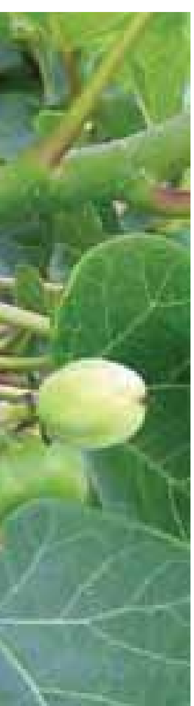
ICRISAT and AVRDC awarded for joint efforts

The world's agricultural researchers have bestowed on ICRISAT and the World Vegetable Center (AVRDC) the prestigious Science Award for Outstanding Partnership for improving the lives of women and children in West Africa. The award was presented to both ICRISAT Director General Dr William Dar and Dr Dyno Keatinge, Director General of AVRDC, at the Global Conference on Agricultural Research for Development (GCARD) on 29 March in Montpellier, France.

"This ICRISAT–AVRDC partnership in West Africa has massively improved the lives of countless West African children and women. I am extremely proud of this outstanding work of my colleagues," stated Dr Nigel Poole, Board Chair of ICRISAT. Over the last decade, ICRISAT and the AVRDC have labored jointly across the Sahel to improve local vegetable varieties and create viable systems of production. Examples also include the African Market Garden and Bioreclamation of Degraded Lands projects (see below). ICRISAT–WCA is grateful for and proud of this award.

Breeding vegetables for diversity

Okra, moringa, and ICRI-Xina were the focus of the breeding and promotional efforts of ICRISAT and the AVRDC's award-winning collaboration. Locally adapted short-duration okra genotypes were purified and maintained, and a total of 95 additional accessions of okra were assembled. The 250 active okra varieties now available represent collections from most parts of the world with either primary or secondary centers of genetic diversity. In collaboration with the University of Niamey and a nematologist of the *Institut National de Recherche Agronomique du Niger* (INRAN), one student has developed a protocol for okra germplasm screening against root-knot nematode. With increased seed production and dissemination, an estimated 200 ha of the improved ICRI-Xina selection was under production in Niger during the 2009 rainy season.



Power to the people with the African Market Garden

Energy is the most limiting factor for the establishment of small-scale horticulture gardens in Africa. Three quarters of the operational costs in gardens is used for labor and energy to pump water. In addition, manual pumps limit the irrigated area, and fuel-based pumps have fast amortization rates and rely on unstable supplies and fuel prices. ICRISAT found that the African Market Garden (AMG) technology greatly enhances profitability of smallholder horticulture producers while efficiently using energy and water.

The AMG is a small-scale horticultural production package based on low-pressure drip irrigation and year-round production of high value crops. Drip irrigation improves growing conditions resulting in higher crop yields, but the biggest advantage is the saved time and labor. For a 500 m^2 vegetable garden, it takes about 10 minutes to operate the drip kit, whereas it takes 4 hours per day to irrigate with watering cans (Fig. 6). In addition, water is used more efficiently because only the root zone is moistened instead of the entire plant and surroundings.

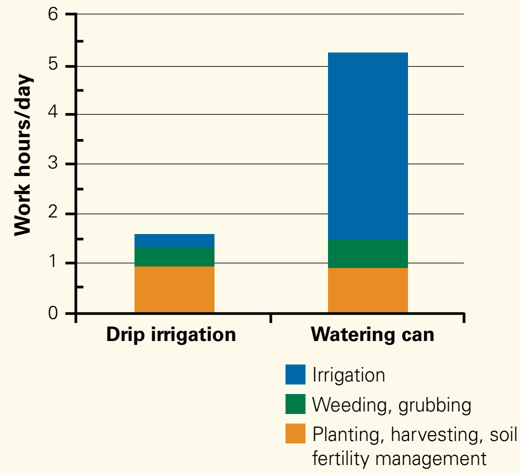


Figure 6. Labor use on a 500 m² vegetable garden for main activities

Woman carrying a cabbage on her head in an African market garden (Duntassa, Benin)

Since the AMG requires only 1 m of pressure for operation, it can draw on low-capacity renewable energy sources such as solar, artesian pressure, or gravity from low elevation. The latter concept was first introduced in 2006 in three villages in northern Ghana, where a dam elevated 3 m above the field was connected to a pipe network to provide water and pressure to a cluster of twenty 500 m^2 AMG units. In 2009, drip irrigation covering 5 ha was connected to an underused artesian borehole in southern Niger that had been drilled in 1970. Producers grow newly introduced vegetable varieties like sweetcorn, bolting-tolerant lettuce, and fruit trees without having to rely on pumps and fuel.

Solar-powered pumps require little maintenance, have long lifetimes, and rely on a resource abundant in the Sahel: the sun. Irrigation through solar pumping is self-regulatory, as solar radiation is the driving force behind both solar pumping capacity and crop evapotranspiration. In other words, when it is hot and radiation is high, plants require more water – and more water is being pumped. ICRISAT adapted and combined two cutting-edge technologies, solar pumping and drip irrigation, to fit the needs of the poor. In Benin, three women's groups have been using this for the last 3 years to produce year-round vegetables, showing a significant impact on income and health in their community. Each woman generates on average US$200 per year from only 120 m^2 vegetables. Young girls are especially happy, as they no longer have to spend hours fetching water for irrigation. ICRISAT installed 3 ha of solar-powered AMGs in Niger and received support for the expansion of the project in Benin to four more villages. The use of low-capacity alternative energy sources makes this technology especially attractive to Africa's smallholders.

Women reclaim degraded lands – and gain power

The Bioreclamation of Degraded Lands (BDL) system is designed to convert the degraded, crusted laterites of the Sahel back into productive lands. It combines traditional water harvesting techniques with hardy trees and indigenous vegetable crops. The BDL has a multi-purpose function: it provides solutions to aspects of income generation, nutritional imbalance, empowerment of women, food security, climate change, and biodiversity conservation.

From 2007 to 2009, research was carried out in hard and soft-crusted lateritic soils. Among seven tree species under investigation, *Acacia tumida* was found to perform extremely well in the hard lateritic soil and is a potential candidate for the establishment of renewable firewood plantations. In a year that saw only 500 mm rainfall, okra yield was 3 t/ha and the leaf yield of 3-year-old *Moringa stenopetala* was 9 t/ha – a total value of about US$1500/ha.

The results show that vast wastelands of degraded lateritic soils in the Sudano Sahel can be reclaimed by using appropriate water harvesting technologies combined with suitable plant species. Pure plantations of *A. tumida* can be established for production of renewable firewood and high-protein seeds. Additional species such as *Acacia senegal* or *Sclerocarya birrea* can be used for production of gum arabic or fruit juice and nuts respectively. Tree plantations add organic carbon to the soil and should significantly increase the productivity of pasture plants by improving soil fertility, reducing soil erosion, and increasing water infiltration. The main potential impacts are:

- The existence of renewable firewood plantations will ease the current destruction of the indigenous woody species that are used for firewood while facilitating their regeneration.
- Women gain the ownership of land and the possibility of earning income, resulting in their empowerment. This has a direct positive impact on the health and education of children.
- Bringing abandoned lands back into cultivation eases the increasing pressure on land caused by the burgeoning population of the Sudano Sahel.
- Availability of highly nutritious vegetables, in particular leafy vegetables that can be harvested at 2 months, can provide significant nutrition during the 'hunger period', when grain reserves have dwindled and new stocks are not yet available.
- The use of water harvesting techniques and tree planting in lateritic soils, which have higher water-holding capacity than sandy soils, can significantly mitigate the effects of climate change.

The research for development of BDL is still ongoing, but based on women's uptake of this technology it seems that this promising system for the Sudano Sahel could be upscaled. Larger pilot studies should be taken to test the various models of BDL in the countries of the Sudano Sahel.

A women's success story

In the Sudano Sahel, women are denied the right to own croplands. Degraded lands however, are often found in community lands under the jurisdiction of the village chief, who can in many instances allot them to women's groups. One women's association was created at the Sadoré village close to ICRISAT's research station in Niger. Its leadership was democratically elected. The association distributed a 200 m^2 plot of degraded land to its members. In each plot there were four trees of either *Pomme du Sahel* (*Ziziphus mauritania*) or of *Moringa stenopetala* intercropped with traditional vegetables. Sadoré women preferred the cultivation of okra to that of other vegetable species.

After the planning phase, the women's BDL was established in May 2006. A 2 ha field of soft laterite was cultivated by 100 women from the association. They planted the short-duration Koni okra variety, thinning seedlings to one plant per planting pit and adding manure. In 2009, the fruit weight of okra from plots of 23 randomly selected women was recorded at each harvest. Leaves from 3-year-old *M. stenopetala* were harvested in September. The okra fruit and the moringa leaves were dried and stored to be used by the women's families. Okra fruit yield was about 3 t/ha and leaf yield of 3-year-old *M. stenopetala* was 9 t/ha, giving a total value of about US$1500/ha or US$30 per woman.

Inspired by this success, pilot BDL sites were also established in the Dosso and Zinder regions of Niger. In Dosso, women's groups are planting two traditional vegetables – *Roselle* and *Senna obtusifolia* – in planting pits. This simplified technology is spreading fast. While in 2007, only about 7 ha were planted in two villages, by 2009 the planted area increased to 67 ha in 20 villages.

Saving for the future: ICRISAT's gene bank for WCA

The conservation of plant genetic resources (PGR) is a prerequisite for their future use. PGR play a key role in the development of stress-resistant, high-yielding, and high-quality cultivars of major crop species. They also offer farmers production alternatives for higher income. Against this background, in 1991 ICRISAT established a gene bank at the ICRISAT Sahelian Center in Sadoré, with the following objectives:

- Conserve sustainable germplasm in the region
- Disseminate healthy germplasm
- Characterize germplasm collections
- Support training and capacity building
- Publish documents related to plant genetic resources conservation, characterization, and use.

Over 36,485 accessions are preserved in two cold rooms (2°C and 16°C) and 20 deep freezers. Additionally, there is a seed laboratory for germination tests, seed inspection, and packing; a greenhouse for raising delicate accessions; and irrigable fields for the conservation of tree species.

The 2°C cold room of the ICRISAT gene bank at our regional hub in Niger

Collections conserved ex situ *in the gene bank*

1. ***Active or working collections:*** Accessions are drawn for distribution, regeneration, evaluation, and use.
2. ***Base collections:*** Accessions from the base collections are not used as a routine source of distribution of germplasm but as a security against loss.
3. ***Safety duplicates:*** These include many from the global collection of groundnuts, pearl millets, and finger millets.
4. **Ex-situ *living plants collection:*** In 2001, we started a collection of tree species and varieties to provide vegetal material for propagation. We also aim to become a reference collection center of useful trees in the semi-arid tropics of West and Central Africa. The fruit trees are planted under drip irrigation. Collections cover a wide range of local and exotic useful species including fruit trees, vegetable plants, and vegetable oil species. A total of 151 varieties representing 40 species are now planted.

The World Bank Gene Bank Upgrading Project significantly strengthened the ICRISAT-Niamey gene bank in Niger, which aims to develop into a regional center of conservation of Sahelian plant genetic resources. The project helped to process new germplasm for the gene bank, identify and regenerate critical groundnut and sorghum accessions (e.g. those having low seed quantities and/or low germination rates), characterize the sorghum accessions and upgrade the characterization database, and replace old items with new capital equipment.

From 2007 to 2009, a total of 9551 germplasm accessions were processed and an additional 1836 accessions are currently being processed as result of the project. Furthermore, 5293 sorghum and groundnut accessions were regenerated. The projected outputs were therefore largely outperformed (Table 4).

Table 4. Number of accessions processed and regenerated by the ICRISAT-Niamey gene bank from 2007 to 2009 with the support of the GPG2 project.

	Processed accessions			Regenerated accessions	
Year	**Sorghum**	**Groundnut**	**Small millets**	**Sorghum**	**Groundnut**
2007	3052 [a]		3042	207	1550
2008	207	1550		200	1500
2009	200	1500		296	1540
2009/10 [b]	296	1540			
Total	**3755**	**4590**	**3042**	**703**	**4590**

a) Safety duplicates; b) Still underway.

In 2009, we distributed the following from the gene bank:

- 322 sorghum germplasm accessions
- 10 pigeon pea accessions
- 21 groundnut accessions
- 1207 pearl millet accessions (in cooperation with the ICRISAT–Niger pearl millet program).

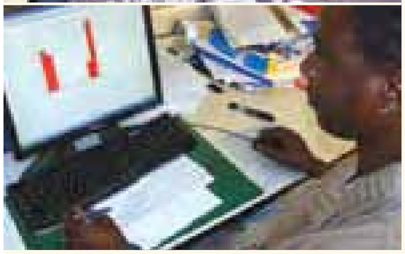
Perspectives of the ICRISAT-Niamey gene bank

The vision and aim for the gene bank at ICRISAT-Niamey is to develop into a regional plant genetic resource conservation center for Sahelian crop species. WCA region NARS are currently being encouraged to place safety duplicates of their Sahelian crop collections into the gene bank. However, as space and funds are limited and electricity costs very high, long-term financial support is needed to support this development.

At the Centers: ICRISAT activities

Diversifying skills: ICRISAT training for farmers and technicians

In 2009, ICRISAT invested considerable effort in organizing several training workshops. Some highlights:



Beyond the data: Scientists' responsibility

One two-part statistic course for technicians and assistants was conducted by Dr Roger Stern from the University of Reading and Gaston Kokodé from Benin. Among the 43 participants were representatives from ICRISAT, several NARS, and the Japan International Research Center for Agricultural Sciences (JIRCAS). The course covered data exploration and initial data analysis, and highlighted the importance of ensuring that the basic analysis corresponds to the design and that all preparatory steps such as coding are taken. The course also offered participants the chance to practice Genstat, a statistic program developed at the University of Reading. "It is important for technicians to know where their responsibility in data analysis ends and where that of scientists begins," Dr Stern stated.

Dr Stern also led a training workshop for breeders and research assistants involved in pearl millet improvement in WCA. It included a hands-on field training on pearl millet variety multiplication and two full days on multilocation data analysis in Genstat. At our Samanko research station in Mali, we organized a 10-day training workshop for eight technicians and scientists from the NARS of Mali, Niger, and Nigeria in breeding techniques, data capture, analysis, and report writing. We then compiled two guides summarizing the entire workshop. They are available in English in hard and soft copies.

Production, multiplication, and storage of vegetable seeds

Within the framework of their collaboration, ICRISAT and AVRDC organized several training sessions on handling vegetable seeds, both on-station and on-farm.

Initially Prof Dov Pasternak anticipated only 25 participants for his training session on multiplication and storage of vegetable seeds at the Sadoré research station. But a total of 67 farmers came from Benin, Burkina Faso, Mali, Niger, Senegal, and Togo for the course, which was a continuation of a nursery management session held in December 2008. The aim was to teach producers of vegetable seeds how to improve quality, select the right types, and stock them in a proper way. "But the actual selling you have to do yourself", commented Pasternak, to the laughter of the participants.

We also trained forty new moringa seed producers from Niger and provided them with 50 kg of seeds of the superior variety PKM-1. Its leaf yield is about three times greater than that of the local varieties and its taste is considered superior by farmers. Another 100 moringa growers were trained in optimal plantation management. We expect that within 3–4 years we will see increased moringa production in Niger and in neighboring countries.

Yet another group of farmers had on-farm training to expand their vegetable growing season. Empowered by the previous training on seed production, many farmers in Niger are now producing seeds of exotic vegetables such as Maya lettuce and ICRI-Xina tomato.

Harvesting sweet sorghum

In Mali, the Samanko research station hosted a training program on best practices for harvesting sweet sorghum for collaborative trials, with scientists, technicians, and students from IER and ICRISAT participating. We aimed to enhance the understanding of the different steps for harvesting sweet sorghum, from determining the optimal harvest date and sampling strategies for biomass to grain yield evaluation and juice extraction.

Seed enterprise

In Mali, ICRISAT organized a 3-day intensive training course on small-scale seed enterprise management. The objective was to share business skills with groundnut and sorghum farmers in seed business management. A total of 24 groundnut and six sorghum farmers across several regions participated. Based on project experiences, the training was structured to meet their needs, which include information on management of revolving funds, stock management, sales and marketing, small-scale enterprise management, calculation of production and sales price costs, and business relationships.

Seed inspectors

The Niger section of the West Africa Seed Alliance (WASA) in partnership with the Seeds, Legislation and Quality Division of the Ministry of Agricultural Development and INRAN, organized a seed inspectors training session for the Maradi region. Currently the agricultural service in charge of quality seeds control lacks sufficient human resources and relevant training in order to ensure effective quality control. Hence inspectors were trained in administrative procedures, field control norms and criteria, sampling techniques, and labeling and packaging of seeds.

Welcome to ICRISAT: 2009 events

Governing Board meeting

ICRISAT's Governing Board met for the 61st time in Bamako, Mali. Attending the meeting were the 10 board members (minus Andhra Pradesh Chief Secretary Ramakanth Reddy) with its new Chair, Nigel Poole, at the helm. A highlight was the visit of ICRISAT Director General William Dar to the President of Mali, His Excellency Amadou Toumani Touré. The president praised ICRISAT's efforts in increasing the productivity of sorghum, groundnut, and pearl millet. Amongst other topics, the Board discussed items relating to the CGIAR change management process, trends in development assistance, the world financial outlook, and the framework of ICRISAT's strategic planning process and ICRISAT's Climate Change Risk Management Strategy. The 4-day meeting was rounded up by a visit to Mali's national historical museum and ICRISAT's Samanko research station, where Board members were briefed about major research projects. Media coverage was substantial, including reporting by a regional television network.

Two end-of-project events

ICRISAT hosted a colloquium to mark the end of two 3-year projects in West Africa: Project Millet and Sorghum – Growing out of Poverty (PROMISO) and Mobilizing Regional Diversity for Creating New Potentials for Pearl Millet and Sorghum. ICRISAT, the leading institute for both projects, was in full attendance, with scientists representing India, Mali, and Niger. Together with 59 representatives from NARS, universities, advanced research institutes, non-governmental organizations (NGOs), development projects, and farmers' organizations, they reviewed progress achieved during the last 3 years and drew conclusions for the future. The main conclusions and results of the project have been compiled in a publication available in English and French at ICRISAT's research stations in Niger and Mali.

Another workshop was held in Niamey for the CGIAR Systemwide Livestock Program project Reducing the Vulnerability of Pastoral and Agro-pastoral Systems to Climate Change in East and West Africa. Twenty participants from these two regions and the USA shared their findings and drew useful lessons from similar ongoing projects. They represented organizations such as the International Livestock Research Institute (ILRI), ICRISAT, INRAN, and the University of Wisconsin, as well as development partners from Niger.

Annual days in Niger and Mali

ICRISAT–WCA celebrated its Annual Days 2009 at Sadoré and Samanko stations in Niger and Mali. These were great opportunities to look back on a labor-intensive and successful year and to honor staff members. The team of Head of Finance Hassane Amadou won the prestigious Soccer Annual Day Trophy with two landslide victories.

ICRISAT-Mali celebrated along the Niger River outside Bamako. Amadou Sibe, the Chair of Personnel Council, enlivened the accession with hilarious stories. Staff members enjoyed games including chess, skits, ludo, cards, and Pétanque. Laure Anthony, Head of the Finance Office in Niger, received a distinction for her 25 years at ICRISAT. Also awarded were four members of the ICRISAT-Mali team for their 20 years, among them sorghum breeder Eva Weltsien-Rattunde.

Sharing our successes

This year we welcomed farmers and several VIPs, from ministers and NGOs to delegates of international development organizations to our research stations in Mali and Niger. Here are some examples:

Open field days in Niger and Mali

In September, when the harvest season is approaching, it is time for us to open our doors for visitors. In Niger, together with its national partner INRAN, ICRISAT organized two Open Field Days in the town of Maradi and at Sadoré research station. Government officials, representatives of international organizations and NGOs, as well as farmers, joined to have a close look at ICRISAT's research efforts. Among the visitors were representatives of the Egyptian and French Embassies, the Belgian Development Cooperation and the Consul General of Mali. About 80 participants were guided through the research fields.

In Mali, a total of 145 farmers were welcomed by ICRISAT. The field visit was translated into Bambara, the local language. The second day was devoted to development partners, heads of missions, NGOs, farmers' organizations, the public sector, agro-dealers, seed entrepreneurs and IER, altogether about 100 visitors. The USAID mission in Mali and GTZ were present with a strong delegation.

GTZ visits ICRISAT-Niger – Climate change and collaboration

Although he originally proclaimed an exclusive interest in fruits, vegetables, and Jatropha during his visit to ICRISAT's Sadoré research station, Dr Werner Petuelli, Director of GTZ in Niger, clearly became fascinated by the whole range of ICRISAT's technologies and proposed an initial collaboration with ICRISAT. In fact following this visit, ICRISAT scientists assessed evaluations in two of GTZ's intervention zones.

A second delegation of 35 representatives from the GTZ headquarters in Germany and its hubs in West Africa followed some months later to learn about ICRISAT's strategy in view of climate change in West Africa's semi-arid tropics. Principal Scientist Bettina Haussmann gave details on genetic diversification as a means to deal with climate change, referring to the BMZ-funded project Mobilizing Diversity for Creating New Potentials for Pearl Millet and Sorghum Farmers in West and Central Africa. The visitors engaged actively in discussion with ICRISAT scientists and expressed their wish for further collaboration in combating the challenges of climate change in WCA.

USAID – Seeds and the food crisis

A United States Agency for International Development (USAID) delegation comprising Mr Henderson Patrick, the West Africa USAID Mission Director, and Jean Harman, Accelerated Economic Growth Office Director of USAID in Mali, visited ICRISAT's research station in Bamako. Mr Patrick was chiefly interested in the progress made by ICRISAT as the lead implementing organization of the USAID-funded Seeds Project of WASA. With the same objective, another USAID delegation led by Dr Robert Kagbo, Senior Agricultural Advisor of USAID–West Africa, was visiting the Seeds Project achievements in the Sikasso region. The visitors expressed their satisfaction with the progress of the project, which is expected to continue.

Another delegation of USAID experts from Accra, Dakar, Niamey, and Washington DC met with ICRISAT scientists at Niamey. They wanted to identify ICRISAT's scale of intervention and best technologies that would help address the food crisis and high food prices in West Africa. ICRISAT scientists presented our key research activities and achievements, including crop and system diversification, fertilizer microdosing combined with a warrantage – or inventory credit – system, and improved varieties.

World Bank – "A sound strategy"

The World Bank Representative in Niger, Mr Ousmane Diagana visited ICRISAT Sadoré. Mr Diagana was guided through the gene bank and met scientists who presented their experiments. The World Bank in Niger and ICRISAT–WCA have been collaborating in West Africa to share knowledge and provide technical support on dryland agriculture. This partnership allowed ICRISAT to conduct training courses and evaluate Acacia senegal plantations established throughout Niger for reclaiming degraded land, gum production, and carbon sequestration. At the end of his visit, Mr Diagana wrote the following comment in the visitors' book, "ICRISAT at present concentrates on what the World Bank thinks is a sound strategy and we will promote and support programs and projects like this".

CIRAD – A sign of time passing

Dr Rolland Guis, Advisor for Africa of the DDG Research and Strategy at CIRAD, visited Sadoré research station. CIRAD and ICRISAT collaborate in West Africa in the field of sorghum improvement – precisely sweet sorghum and abiotic stress – as well as pest management. Sadoré-based CIRAD scientist Alain Ratnadass introduced Dr Guis to our programs. Dr Guis stressed, "It is evident that ICRISAT has greatly advanced its research work in the region". When Regional Information Officer Tobias Dierks pulled out the camera for the group photo, Dr Guis commented in a dry tone: "During my last visit at ICRISAT I still had long hair. Now, this photo is proof that this was a long time ago."

UNDP – Firm handshakes

Mrs Khardiata Lo N'diaye, National Representative of UNDP in Niger, visited Sadoré station accompanied by Mr Aly Adamou, Communication Officer at UNDP, and Mr Amadou Saley, Deputy National Representative of FAO in Niger. They were taken around the crop diversification program, nursery, groundnut research fields, pearl millet off-season fields, the BDL sites, and the gene bank. The representative of FAO assured Mrs Lo that his organization would support any further collaboration with ICRISAT since those already existing had been very effective so far.

AVRDC – Continuous collaboration

The World Vegetable Center (AVRDC) Director General Dyno Keatinge visited Sadoré research station. Naturally, his focus was on the AVRDC/ICRISAT vegetable-breeding project. He inspected the vegetable breeding fields and experimentations on fruit tree plantations, and was keen to know about progress in okra breeding, which is part of the joint project conducted by AVRDC scientist Dr Sanjeet Kumar. Dr Keatinge emphasized his willingness to strengthen future collaborations between the two centers, on both a regional and a global level. This collaboration is evident in the partnership award given to AVRDC and ICRISAT by the CGIAR (See page 21).

FAO – Benefiting local communities

The Representative of the Food and Agricultural Organization of the United Nations (FAO) in Niger, Mr Moustapha Cassama, visited Sadoré. Scientists took him on a field visit focusing on seed multiplication and crop diversification activities at Sadoré village and also to the gene bank and the soil laboratory. Mr Cassama expressed his desire to develop collaboration with ICRISAT on projects for the benefit of local communities based on the Sadoré village model.

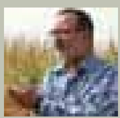
ICRAF – Strengthening our partnership

The Director General of the World Agroforestry Center (ICRAF) Dr Dennis Garrity visited Sadoré, accompanied by Antoine Kalinganire, the Agroforestry representative based in Bamako, Mali. Dr Garrity was particularly interested in the domestication of local fruit trees and conservation practices such as *zaï* holes and half-moons. He proposed to endorse even stronger ties between ILRI and ICRISAT. In fact a new joint post will be created in 2010.

Who we are

List of scientific staff

NIAMEY, NIGER



Farid Waliyar
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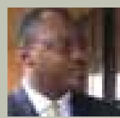

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Assistant Regional Director (from August 2009) and Principal Scientist
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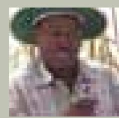

Ramadjita Tabo
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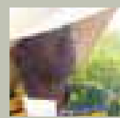

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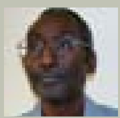

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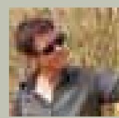

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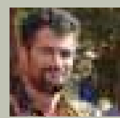

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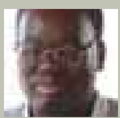

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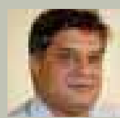

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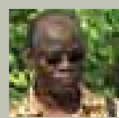

Albert Nikiema
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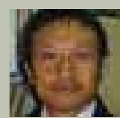

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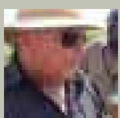

Dov Pasternak
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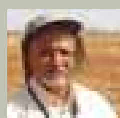

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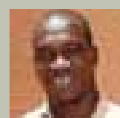

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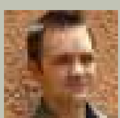

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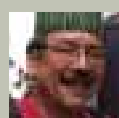

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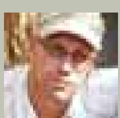

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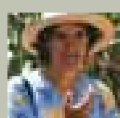

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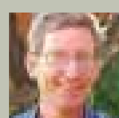

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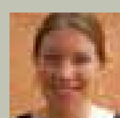

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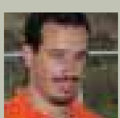

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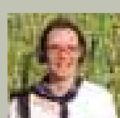

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