Sowing Seeds of Success

ICRISAT Research Impacts 1997-2003

Foreword

This booklet summarizes the accomplishments and impacts of ICRISAT from 1997 to 2003. Our successes in these endeavors is proof positive that ICRISAT has competently and enthusiastically addressed the major challenges facing agriculture in the semi-arid tropics.

Much of our success has been achieved by improving our five mandate crops – chickpea, pigeonpea, groundnut, sorghum and pearl millet. Our remarkable successes with crop improvement have been widely recognized. Between 1997 and 2003, ICRISAT received more than 40 team and individual awards. Of these, none were more prestigious than our King Baudouin Awards. This biennial prize is awarded to the CGIAR institute achieving the most visible impact over the preceding two-year period. ICRISAT has won this award an unsurpassed *three times*. In 1996, we won the award for our success with pearl millet. In 1998, we won the award for the second time in a row for our work with pigeonpea. And in 2002, along with our sister center ICARDA, we completed the hat trick with our research on chickpea. Three victories out of four nominations is an achievement no other center has yet accomplished!

But we are not about to sit on our laurels. ICRISAT intends to move forward ever more vigorously with its partners, sowing further seeds of success. Our ultimate goal – winning the Grey to Green Revolution in the semi-arid tropics – is within our grasp.

William D Dar
Director General

Saving lives and money with diagnostic kits

Aflatoxins kill. These murderous fungi contaminate groundnut products grown for consumption by both humans, who eat the groundnuts themselves, and livestock, which feed on the haulms and the cake product rendered after extracting the crop's oil. Medical research has revealed that people whose livers have been debilitated by hepatitis are extremely high risks for cancer if they consume aflatoxins. Detecting the presence of these hazardous toxins is therefore an extremely important health priority.

Conventional procedures to detect aflatoxin are reliable but time-consuming and expensive. ICRISAT scientists took a hard look at the problem and set about developing a simple, cost-effective tool using a diagnostic tool called enzyme-linked immunosorbent assay (ELISA). The new test costs only $3 per sample as opposed to the previous figure of $18. The impact was immediate. Feed producers and poultry farmers have energetically adopted this technique. One Indian feed manufacturer, which has improved its annual turnover to more than $4 million, has attributed its new prosperity to its use of ICRISAT's new ELISA technology.

Upstream research results in huge savings for downstream farmers.

Leading the pack

ICRISAT's expertise in biotechnology was recognized at the 2003 Annual General Meeting of the CGIAR in Nairobi when Dr Jonathan Crouch, Global Theme Leader for Biotechnology, was presented with the CGIAR Science Award for Promising Young Scientist. Dr Crouch i has been a leading light in formulating new policies and protocols for our increasingly close collaboration with research partners from the private sector. At the same time, he and his team have nurtured our traditional collaborative ventures with the public sector and NGOs.

Dr Crouch with his award. He is flanked by Director General Dar and Board Chair Mukwunye.

In 2001, Dr Crouch launched an initiative that attracted national funding to establish an Agri-Business Incubator in 2002. A year later, he established our in-house Intellectual Property Management Office and was chosen as one of three CGIAR members for the Central Advisory Service on IPR (along with the Directors General of CIMMYT and IRRI). Most recently he has been championing the establishment of a Biotech Awareness and Biosafety Support Unit.

Making miracles with molecules

Any doubts about the impact of marker-assisted selection in India's pearl millet belt are dispelled with a glance at this farmer's field – and his smile!

One of the first things ICRISAT did after establishing its headquarters near Hyderabad in the mid seventies was to initiate partnerships with important universities. None has been more fruitful than our relationship with Haryana Agricultural University (HAU). In fact, ICRISAT viewed this relationship so important that we maintained an office there for nearly two decades.

The superb pearl millet breeding team at HAU, backstopped by ICRISAT researchers, was

responsible for developing the most widely sown variety in India, a popular early-maturing hybrid called HHB 67. HHB, by the way, stands for Haryana Hybrid Bajra – *bajra* is the Hindi word for pearl millet. ICRISAT's role in developing this important variety, which tolerates the most difficult adversary of pearl millet, downy mildew disease, was in supplying the hybrid's parental lines from our headquarters.

The HAU-ICRISAT team had created an excellent variety, high-yielding and disease-resistant. But they knew their work was not done. Plant diseases, like all organisms, have a Darwinian urge to survive. Like an expert burglar picking a lock, pathogens will eventually ferret their way through the defenses put in their way by scientists. And once a pathogen figures out how to pick a lock, the crop would once again become susceptible.

Except that these scientists were ready. Utilizing marker-assisted backcrossing, the collaborating scientists developed – and continue to develop – versions of HHB 67 with improved levels of disease resistance, drought tolerance, and grain and stover yield potential. The impacts that have sprung from this singular collaboration include the development of several improved pollinators and seed parents that have been passed to private seed companies, along with information comparing the hybrids of these lines with the original HHB 67 for disease reaction and agronomic performance. These improved versions of HHB 67 are expected to replace the original, which must eventually succumb to downy mildew.

Do the farmers of Haryana like the new versions? Indisputably. They made their preferences clear during on-farm comparisons of these improved versions with the original in 2003, and this information will contribute to the continued development of new versions, extending indefinitely the economically useful life of this exceptionally popular hybrid.

Chickpea on the march

To date, over 100 improved varieties developed by ICRISAT and its partners have been released in 27 countries. Areas sown to chickpea and productivity have increased dramatically throughout the tropics, and large new production areas have been opened. The impact of ICRISAT's success with chickpea led to the institute's third King Baudouin Award in 2002, which we shared with ICARDA.

Some examples of ICRISAT's remarkable achievements with chickpea around the globe:

- *India, Sudan and Myanmar.* ICCV 2, an extra-short-duration *kabuli* variety that escapes terminal drought, has been successfully released in these three countries, representing completely different regions.
- *Australia and Canada.* In these two developed countries, where chickpea was virtually unheard of ten years ago, ICRISAT-derived varieties are spreading like wildfire. In Canada, over half a million hectares are presently sown to chickpea. One third of this area is cultivated with a single ICRISAT variety called Myles.

- *Gujarat, India.* The net income from the new ICRISAT-derived cultivar ICCV 10 was 84% more than the local variety. Moreover, the cultivar was 23% cheaper in production costs.
- *Maharashtra, India.* Chickpea varieties developed by ICRISAT now occupy nearly 40% of the total area. Adoption of these varieties yielded farmers an additional net benefit of $80 per hectare.
- *Andhra Pradesh, India.* ICRISAT varieties now occupy a third of the area sown to chickpea. The farmers who adopted these varieties earned $55 more per hectare than farmers using other varieties.
- *The Barind, Bangladesh.* Asia's poorest farmers are sowing more chickpea every year in their rice fallows, providing a completely new source of income.
- *Tanzania and Kenya.* Collaboration with two large international NGOs, Catholic Relief Services and TechnoServe, and several local farmer organizations, has introduced chickpea into new areas, generating incomes of some of Africa's poorest farmers.

Peas for prosperity

The impact of ICRISAT's pigeonpea research led to our second King Baudouin Award in 1998. Since then, the impact has continued to increase. More than 800,000 hectares in the Indian states of Andhra Pradesh, Maharashtra and Karnataka are now cultivated with two ICRISAT-derived varieties, ICP 8863 (Maruti) and ICPL 87119 (Asha). Another four varieties are grown on about 85,000 hectares in southern and eastern Africa. Pigeonpea is emerging as an important crop for fodder, fuel and soil conservation in southern China, where it has rapidly increased from almost zero cultivation in 1998 to about 60,000 hectares in 2001.

Traditionally a South Asian crop, pigeonpea has become a staple food in East Africa.

Much of this success had to do with ICRISAT's work in reconstructing the crop into earlier-maturing, shorter-statured, higher-yielding varieties. This work stimulated large productivity gains, diversified cereal-dominated cropping systems and triggered a major geographic extension of the crop.

ICRISAT created ICPH 8, the world's first food legume hybrid. The work took a long time – nearly two decades of painstaking research – but the proof of the pie is in the eating, and the poor farmers of the

Pigeonpea has been revived in China, providing new options for farmers on marginal lands.

semi-arid tropics are now able to enjoy the benefits of the increased yields that hybrid crops offer. ICPH 8 is now under commercial production, demonstrating a 25% grain yield increase, additional stem and leaf biomass for fuel and forage, as well as improved tolerance for drought, disease and waterlogging.

Another breakthrough in pigeonpea research came about in 2000, when ICRISAT scientists identified the elusive cause of sterility mosaic disease. The virus is responsible for annual production losses worth more than $300 million.

The importance of this nutritious legume is increasing by leaps and bounds in eastern Africa, where farmers in dry areas are finding the crops an excellent intercrop with cereals. ICRISAT scientists, working in intimate collaboration with a range of partners, have succeeded in enriching the lives of thousands of poor farmers.

Sorghum – staple food for hungry people

The impact of sorghum bred by ICRISAT and its partners continues to make waves. Between 1997 and 2003, 18 cultivars were released by 4 Asian countries and 23 cultivars by 11 African countries. During the same period, ICRISAT supplied an astonishing number – over 70,000 – of sorghum seed samples to over 50 countries. Twenty clients – 12 private seed companies and 8 agricultural universities, to be precise – formally acknowledged that their most promising hybrids were based on ICRISAT-bred hybrid parents, or derivatives developed by them from ICRISAT's hybrid parents.

Sorghum factoids from around the world:

- *Nigeria and Ghana.* Variety S 35 yielded 25% more grain than the popular local, and its adoption rate soared, reaching 15% in Nigeria and Ghana.

Similarly, sales of ICSV 400 increased enormously to 4.5 million Naira ($40,000) in 2001 because of the variety's suitability in the brewing industry. Virtually all Guinness Stout, one of Nigeria's most popular beverages, is brewed from ICSV 400.

- *Botswana.* Phofu, a stay-green, early-maturing variety, is being planted by 21% of sorghum farmers in Botswana.
- *Eastern and southern Africa.* As a direct result of excellent regional collaboration, another sorghum variety, Macia, is now grown on 30% of the sorghum area for its good taste and food quality in Eritrea, Kenya, Mozambique, Namibia, Tanzania and Zimbabwe.
- *Mali.* CSM 63 E, an extra-short-duration variety known as Diacumbe, is making inroads with farmers and is now grown over 10% of the sorghum area in Mali. Its area of cultivation has been continuously increasing. Seven other new varieties have been released in Mali, mostly belonging to the *guinea* race: Tieble (CSM 335), Kossa (CSM 485), Ngolofing (CSM 660), Marakanio (CGM 9-9-1-1), Padi (ICSV 901), Nazomble (Nazangola anthocyané) and Nazondje (Nazangola tan). Tieble and Ngolofing, favored

Macia has brought new prosperity to southern African sorghum farmers.

because of their good yield, relative earliness, and excellent grain qualities, are achieving particularly rapid penetration among farmers in the 800-1000 mm zone of the country.

- *Kenya.* The variety Gadam el Hamam has been adopted by farmers who are impressed with its early maturity and good taste.
- *Niger and Nigeria.* A hybrid called NAD 1 has been released, and both seed production and adoption are increasing. Similarly, hybrid ICSH 88902 has been released in Nigeria.
- *Tanzania.* Variety Pato has been adopted over approximately 36% of the area under improved varieties in this semi-arid country.

The amazing biodiversity of sorghum.

Globetrotting with groundnuts

Of all ICRISAT's crops, groundnut is the most ubiquitous. Groundnuts, also known as peanuts or monkey nuts, grow in various soils and climatic conditions from 40°S to 40°N. The successes of ICRISAT and its partners with this hugely important cash crop has improved the lives of hundreds of thousands of farming families in the semi-arid tropics and elsewhere. ICRISAT-derived groundnuts are thriving in seven countries in sub-Saharan Africa and in nine states of India.

Groundnut factoids:

- *East Timor.* In 2000, ICRISAT participated in an initiative led by the Australian Council on International Agricultural Research (ACIAR) to rehabilitate agriculture in East Timor (now known as Timor-Leste), sowing 80 kg of various high-yielding varieties in trials throughout the world's newest nation.
- *Southern Africa.* Medium-maturing variety CG7 is presently grown on more than 30,000 hectares in Malawi, and has been adopted by half of the groundnut farmers in Zambia.
- *Zimbabwe.* An early-maturing and high-yielding variety, Nyanda, is becoming popular in drought-prone areas. It is currently grown on about 10,000 hectares.
- *Mali.* Early-maturing variety ICGS 36E has been adopted on about 20,000 hectares.
- *Nigeria.* For the first time, an early-maturing, rosette-resistant variety, ICGV-IS 96894, has been released in Nigeria, the largest groundnut producer in West Africa, and one of the largest in the world. Extremely popular with farmers in the groundnut belt, the variety has restored farmer confidence in growing groundnut without losing it to rosette disease, the most devastating disease of the crop in sub-Saharan Africa.
- *Malawi.* ICGV-SM 90704, a medium-duration, rosette-resistant variety

Groundnut means cash for millions of resource-poor farmers.

released in 2000 in Malawi, is gaining ground in rosette-prone areas due to its ability to produce higher yields under epidemic conditions.

- *Zimbabwe.* From materials supplied by ICRISAT, a private company called SeedCo Limited has identified short-duration, rosette-resistant variety ICGV-SM 99537 for release. This variety is likely to meet the long-felt needs of groundnut farmers, adding to the stability of agricultural production in this important country.
- *Mali.* In the Kolokani region of Mali, ICG 7878, a variety that resists foliar diseases, is now planted by 25% of farmers, making a difference in the livelihoods of the poor. Women especially appreciate this variety as it has improved the quality of the daily diets of their families. The income derived from sales of the variety also helps to send children to school. Farmers like Mr Bagi Traoré have profited significantly from sowing ICG 7878. Mr Traoré recently used his new income to purchase a seed planter, bullocks and a new wife!

In East Timor, ICRISAT's improved varieties (left) dwarf the locals (right).

- *Senegal.* Six high-yielding varieties meeting international grades and standards for confectionary groundnuts are now available to farmers for cultivation under irrigation to provide protection against aflatoxin contamination and to promote the groundnut trade. Before 1996, only 13 groundnut varieties were listed as adapted to West African conditions. Thanks to ICRISAT and its partners, no less than 37 new varieties have been added to this list.
- *Southern Sudan.* ICG 12988, an aphid- and rosette-resistant landrace introduced into southern Sudan by Catholic Relief Services, an important ICRISAT partner, through ICRISAT's program in Malawi in 2001, has become very popular with farmers in state of Equatoria. Several tribes, some of which have been displaced because of the civil strife in the emerging country, have adopted this hardy variety.
- *India.* ICGS 44 has become very popular in the Indian states of Andhra Pradesh, Karnataka, Tamil Nadu, Orissa and Uttar Pradesh. In certain areas, it has given higher pod yield than other varieties and has registered high production.
- *Gujarat.* With increasing opportunities for groundnut kernel export from India, confectionary groundnut variety Asha (ICGV 86564) is in great demand in Gujarat, a leading groundnut-growing state in western India.
- *Andhra Pradesh.* In 2000, a sudden outbreak of peanut stem necrosis disease in Anantapur district of Andhra Pradesh caused extensive damage to the crop. Losses were estimated at $60 million during that single year. ICRISAT leapt to the rescue, identifying the causal agent of the disease (tobacco streak virus) as well as alternate hosts. A package of control measures was then devised that was successfully adopted in more than half a million hectares.

- *Northeastern Hill States and West Bengal.* In these non-traditional groundnut areas of India, the crop is becoming increasingly popular with farmers due to the superior performance of such varieties as ICGS 44, ICGS 76 and ICGV 86590.
- *Orissa and Chhattisgarh*. Under the aegis of a project funded by the International Fund for Agricultural Development (IFAD) on participatory improvement of grain legumes in rainfed Asia, groundnut has penetrated the tribal belt in the relatively backward Indian states of Orissa and Chhattisgarh, where tribal farmers have expressed their preference for ICGS 76 and ICGV 86590. In Chhattisgarh, they have initiated their own seed production program, and in Orissa, they have established village seed banks to ensure availability during the subsequent cropping season.

Pearl millet – the orphan crop finds a home

Although pearl millet originated in sub-Saharan Africa, its greatest impact has occurred in India. More than 60% of the total pearl millet area in India – about 6 million hectares – is planted with more than 70 hybrids, 80% of which come from that country's vigorous private sector. Of these hybrids, more than 60 are based on ICRISAT-bred material (mostly seed parents), or on the proprietary hybrid parents developed from ICRISAT-bred improved germplasm. In Africa, the impact of ICRISAT's work with pearl millet impact is most visible in the West and Central African countries.

But the impact of our work with pearl millet goes way beyond the farm level. ICRISAT's initiative in offering its breeding lines and potential hybrid parents to whoever can use them has enormously diversified the genetic base of hybrid programs of both public and private institutions. ICRISAT has developed and

Pearl millet has evolved from an orphan crop into a cash crop.

disseminated a total of 90 hybrid parents, 53 of them since 1997. During a single field day in 2000, for example, more than 50 scientists from the private and public sector in India selected 2,040 breeding lines and potential hybrid parents. More than 12,000 seed samples of selected lines were supplied through a single dispatch.

In Andhra Pradesh, hybrid pearl millets have contributed to employment generation and enhanced income for farmers at the seed production stage. Pearl millet hybrid seed production, most of it conducted during the summer season in a single district, generates an additional income of $1 million a year to farmers. What was an 'orphan crop' just 10 years ago has become big business for resource-poor farmers.

Although the impact of pearl millet in India is more visible, ICRISAT has been focused squarely on the problems and needs of sub-Saharan farmers since its establishment. Our facility in Niger, the ICRISAT Sahelian Center, was set up largely as a base for research on this staple food crop in the world's driest agricultural environments.

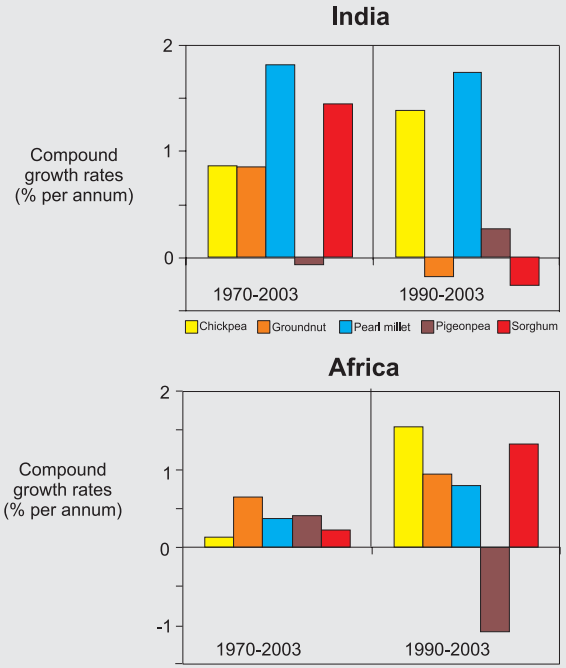
The results have been significant. Variety GB 8735 is grown on 30,000 hectares in Chad and is growing rapidly throughout West Africa. Its early maturity and drought tolerance have enabled farmers to harvest early when household grain stocks are traditionally low. And in Nigeria, variety SOSAT-C88 has become immensely popular, now cultivated on more than 50,000 hectares. In Niger, the demand for improved local varieties, especially HKP Précoce, which is planted on more than 20% of pearl millet growing area in that country, is steady and rising. Adoption is limited only by seed availability, according to the farmers themselves. In Mali, varieties Benkadinio and Toronio, selected in collaboration with the national research program, have rapid adoption rates as a result of sustained efforts of seed production in their zones of adaptation. The adoption area is estimated at 10% of pearl millet growing area. In the Segou and Mopti regions, the earlier-maturing varieties from the program in Niger are also increasingly in demand.

New partnerships with the private sector ensure that the results of ICRISAT's research reach unprecedented numbers of pearl millet farmers.

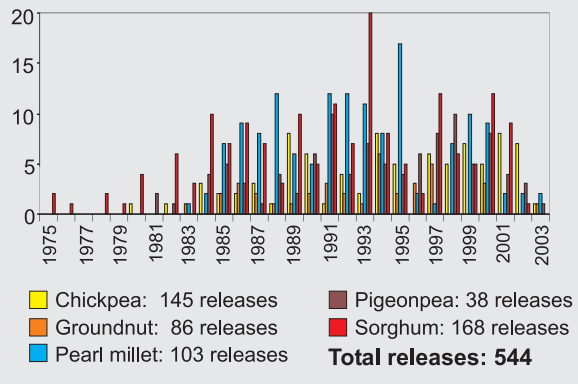
Meanwhile, our pearl millet breeders and their partners have not ignored the dry tropics of East Africa. In Tanzania, variety Okoa has been planted on 80,000 hectares, nearly 30% of the total pearl millet

The graphs on this page show what has transpired during more than 30 years of crop research at ICRISAT.

Productivity gains over the entire history of the institute, as well as over the last 13 years, in India and in Africa



Numbers of cultivars released



Chickpea: 145 releases
Groundnut: 86 releases
Pearl millet: 103 releases
Pigeonpea: 38 releases
Sorghum: 168 releases
Total releases: 544

area in that country. Meanwhile, in Eritrea and Kenya, ICMV 221, a drought-tolerant variety is being cultivated on about 40,000 hectares.

ICRISAT's holy grail – our genetic resources

If ICRISAT were a religion, our genebank would be our inner sanctum, the seeds it holds our holy relics. These seeds are beyond price. How can one put a cost on a seed that represents thousands of years of natural selection and fine tuning by countless generations of farmers? The genetic resources ICRISAT holds in trust for humanity are nothing less than life itself.

When natural or civil calamity strikes and farmers suddenly lose their seeds, they stand to lose a lot more than their planting seed for the next season. Their seeds are their connection to their forebears, their niche on the planet. But because ICRISAT scientists, ever since the institute was established in 1972, have carefully and steadfastly gathered, identified, categorized and stored seeds from every corner of the semi-arid tropics, these farmers can get their holy relics back. Their seeds are *not* lost. They are safely preserved in a high-tech facility built to withstand earthquake, fire and flood.

The Rajendra S Paroda Genebank at ICRISAT-Patancheru holds nearly 114,000 accessions of our five mandate crop seeds, as well as those of six minor millets. Here, our genetic resources specialists have developed a core subset of germplasm, comprising about 10% if the entire collection, to enhance efficient utilization in research. Additionally, several 'mini core' subsets, about 1% of the entire collection, have been assembled for testing at several locations in Asia and sub-Saharan Africa. Besides collections from other countries, unique and threatened seeds have been collected from

Our greatest asset – the genebank.

Bangladesh, Mali, Mauritania, Tanzania and Vietnam as a result of the germplasm acquisition agreements between ICRISAT and each of these countries.

The ICRISAT genebank has supplied thousands of germplasm samples to various research institutes globally. From such seed materials, 12 accessions (8 sorghum, 2 chickpea, 1 groundnut and 1 barnyard millet) were released for commercial cultivation. Countries of releases include Australia, Bangladesh, Eritrea, India, Kenya, Malawi, Mali, Mexico, Rwanda, Sudan and Uganda.

But perhaps the most valuable use of our seed collection was the opportunity it gave us to identify new sources of resistance to biotic and abiotic stresses. Examples include 13 sorghum accessions for resistance to shoot fly and 15 accessions of wild sorghum for spotted stem borer. In pigeonpea, hundreds of resistant accessions were identified: 460 to wilt, 706 to sterility mosaic disease and 7 to phytophthora blight. In groundnut, new resistant sources were found for early leaf spot (26 accessions), late leaf spot (24), bud necrosis (4) and *Aspergillus flavus* (8).

In 1999, the Indian Council of Agricultural Research (ICAR) requested us to duplicate the seeds of 44,822

germplasm accessions that had either been donated to us by the Indian government or collected in collaboration with India's National Bureau of Plant Genetic Resources (NBPGR). We complied immediately – 43,913 accessions have already been repatriated to NBPGR, New Delhi.

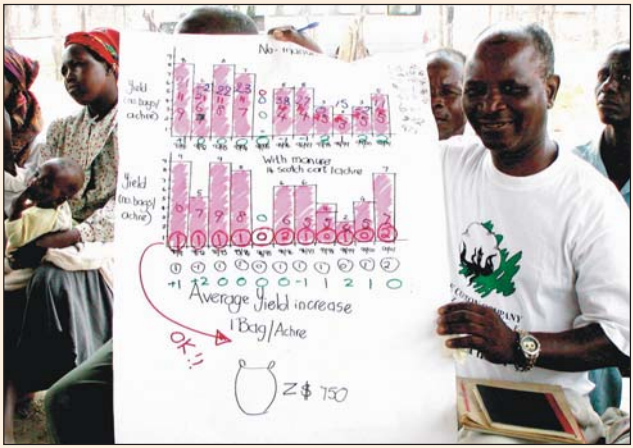
Hitting paydirt

ICRISAT's extensive research on legume crop rotations in cereal systems has paid huge dividends for poor farmers. Adding nutritious pulse crops like chickpea and pigeonpea to cereal systems provides improved diets while decreasing dependence on chemical-based inputs. Cautious at first, farmers from Bangladesh to Tanzania have found that sowing legumes in their rice fallows can provide their families with food and cash, provided they sow their seeds while moisture remains in the soil. Giving the legume seeds a head start by priming them has also proved a very useful intervention.

On the high tech side of the natural resource spectrum, simulation modeling has made a significant impact on smallholder farming systems.

Chickpea has brought new hope to the poor farmers of the Barind of Bangladesh. Even when farmers have access to irrigation, they often prefer to plant lucrative chickpea alongside their rice.

In Zimbabwe, simulation models were used to evaluate a range of soil fertility management options with farmers, and then implemented in a collegial approach. Similarly, in Ananthapur district of Andhra Pradesh, simulation modeling showed that intercropping groundnut with short-duration pigeonpea increased groundnut productivity and increased cash returns even in drought years, when compared to a sole crop of groundnut.



Zimbabwean farmers have responded enthusiastically to ICRISAT's simulation models.

In West Africa, ICRISAT has continued to pursue low-cost soil fertility options for resource-poor farmers. The technique of micro-dosing crops by carefully measuring small amounts of fertilizer into each plant hole was developed in West Africa and has resulted in yield increases as high as 120%. A study to synthesize the lessons learned from both a biophysical and a socio-economic standpoint is now under way.

The incomes of farmers using micro-dosing and the *warrantage* (inventory credit) system have increased 52-134%.

Protecting and nurturing water resources has become a major priority for ICRISAT.

Developing community-scale watersheds

The benefits of combining sound water management practices with improved soil, nutrient, crop and pest management options in watersheds are manifold: increased productivity and incomes, higher groundwater levels, greenery, and reduced runoff and soil loss. The same dramatic benefits obtained by Indian farmers from ICRISAT's watershed research have also brought new prosperity to Thai, Vietnamese and Chinese farmers.

ICRISAT pursues a consortium approach to watershed research that incorporates expertise from various international, national and local organizations. Special attention is given to training of national scientists and preparing technicians for the responsibility of undertaking integrated watershed management in partnership with the villagers. At the community level, women have been deliberately empowered through group training.

At the model Adarsha watershed in Kothapally, Andhra Pradesh, which lies about an hour west of ICRISAT's Patancheru headquarters, farmers' incomes increased 3.5 times over the traditional cotton system using the maize/pigeonpea cropping system. The yield of maize alone recorded a two- to three-fold increase over the baseline yields. Is the watershed increasing? Most definitely. The vegetative cover at Adarsha, which was 129 hectares in 1996, had increased to 200 hectares by 2000, and the trend is continuing.

During the 1997-2003 period, 700 farmers from all over India were trained in integrated watershed management. Technology spillover was clearly observed in farmers from nearby watersheds of Nawabpet and Adilabad districts as they adopted the successful practices of Adarsha.

Keeping the bugs out

Factoids of ICRISAT's initiatives in integrated pest and disease management (IPM and IDM):

- *India.* Collar rot, stem rot and bud necrosis – all serious diseases of groundnut in India – have been markedly reduced using resistant varieties developed by ICRISAT and partners. Farmers have been enthusiastically embracing these varieties, and a strong farmer-focused NGO is promoting their widespread use.
- *Nepal.* Botrytis gray mold (BGM) disease of chickpea, the crop's major constraint in that country, has been stifled through application of IDM techniques developed by ICRISAT. Farmers are now applying these techniques extensively, and the results are heart warming. After simply giving up on chickpea because of their inability to manage BGM, hundreds of farmers have adopted the new technologies and resumed chickpea cultivation.

- *India and Vietnam.* After ICRISAT scientists identified sunflower as an effective trap crop for *Spodoptera*, a particularly nasty caterpillar, Indian and Vietnamese farmers have reported savings of $20 per hectare by planting sunflowers around their chickpea fields.
- *South Asia and East Africa.* Following the initial success of village-level nuclear polyhedrosis virus (NPV) technology, which takes advantage of a natural enemy of *Helicoverpa armigera*, the pod borer, numerous village level production units have been established and are functioning well in collaboration with national agencies, NGOs and farmers. More than 1000 extension specialists in India, Bangladesh, Nepal and Kenya have been trained in the use of this virus in pod borer management.
  An agribusiness venture for NPV production has been initiated by the Agri-business Incubator at ICRISAT-Patancheru with a special grant from the India's Department of Science and Technology to produce the virus commercially, and to encourage potential entrepreneurs.
- *West and Central Africa.* The damage wreaked by the tenacious weed *Striga* (witchweed), which sucks the water out of its victims, is being alleviated by a combination of hand-pulling and weeding, appropriate rotation, trap crops, delayed emergence and application of organic fertilizer. These practices are undergoing scaling-up by research partners, and this scourge is no longer the threat it once was for sorghum and pearl millet farmers in the Sahel.
- *India.* In a large pilot IPM project in India, ICRISAT is working with national agencies, NGOs and farmer communities to address pigeonpea and

Packages of recommendations for the control of pests (like the Striga *in the photograph) must be carefully tailored for each farming community.*

chickpea problems in farming systems. A combination of new technologies, such as biological control using viruses and fungi, along with traditional techniques like shaking the plants and encouraging predatory birds, are widely used. Impact has been particularly conspicuous in a self-declared 'IPM village' in Maharashtra, where almost no insecticide is currently used and production costs have been considerably reduced.

- *Rajasthan.* Cultural practices for alleviation of the peanut clump virus disease such as early sowing under judicious irrigation, trap cropping with pearl millet and rotation with dicotyledonous crops, are now available for groundnut producers in India. These practices are undergoing scaling-up on 250,000 hectares of groundnut by the Durgapura Agricultural Research Station, near Jaipur, Rajasthan. Similar practices are under evaluation in West Africa.
- *India.* Use of IPM/IDM packages in several Indian states in cereals-sunflower rotations were found to control disease. Moreover, yields increased from 100 to 153%.

Water – or the lack of it – will continue to be the most challenging constraint to agriculture in the dry tropics.

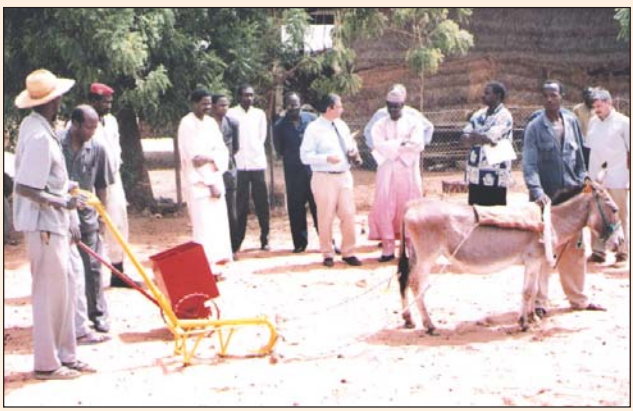
Keeping the sands at bay

Warrantage. With development partners, ICRISAT scientists in Sahelian Africa have formulated a development model that incorporates a rural inventory credit system known as *warrantage.* The *warrantage* scheme ensures that small but key resources are put into the hands of smallholder farmers to ensure the adoption of soil fertility restoration technologies.

Zai. A traditional technology for rehabilitating degraded land was developed by Burkinabe farmers and quantified by INERA, the national research program of Burkina Faso. The technology, known as *zai*, is a technique whereby small quantities of organic material such as manure or compost are inserted into holes bored through the hardpan soil. Plant shoots or seeds are then inserted, and, nurtured by the organic material in the *zai* holes, they thrive. Weed competition is nil because nothing grows on the hardpan soil. Three- to four-fold yield increases can be obtained using this system in very marginal soils with modest applications of manure (3 tons per hectare versus recommended rates of up to

20 tons). Best of all, soil that was previously unusable is now producing excellent food crops. ICRISAT's contribution is the transfer of this superb indigenous technology to other Sahelian countries.

Locally available fertilizer. ICRISAT and the International Fertilizer Development Corporation (IFDC) have identified local sources of rock phosphate that can provide a cheap alternative to imported chemical fertilizers. Significant grain and stover yield increases can be obtained using these locally available phosphates. Specifically, Tahoua, a partially acidulated rock phosphate available in Niger, has proved particularly effective in millet-cowpea rotations, especially when added to modest applications of manure. Using this technique, millet yields up to three times higher than traditional systems are possible. With complementary inputs, grain yields of over 1000 kg per hectare can be achieved.



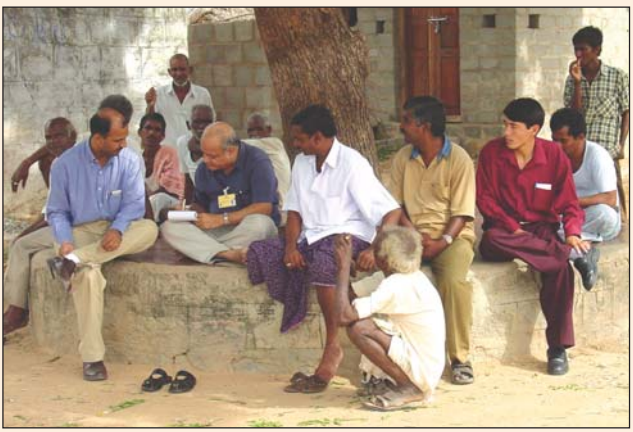
The ingenious HATA saves precious labor time, freeing farmers to pursue additional activities.

HATA. A donkey-drawn weeding implement popularly known as the HATA (*houé a traction asine*) was developed by ICRISAT and University of Hohenheim scientists at ICRISAT-Niamey. The HATA, which is both cost- and time-efficient, was developed to respond to the formidable task of weeding, a major

labor consideration for resource-poor farmers. This implement, which can be obtained in exchange for one 90-kg bag of millet, reduces weeding time to only a fifth the time it takes by hand. Importantly, weeding efficiency is 90% better than manual weeding. Efforts are currently being made to promote its widespread use in the region.

Networking social science

At a meeting sponsored by ICRISAT and FAO on *Social analysis in assessing gender-related impacts of NRM options focusing on buildup of social capital*, a network of social scientists was formed. This network has enhanced the conceptual framework for gender and social analysis. It has also catalyzed interaction with social and biological scientists from universities, NGOs and the donor community. The healthy debate between these partners has clarified that social analysis must look beyond 'one-size-fits-all' approaches to problems, and that impact assessment must consider relevant historical, cultural and social factors when designing and implementing new research initiatives.

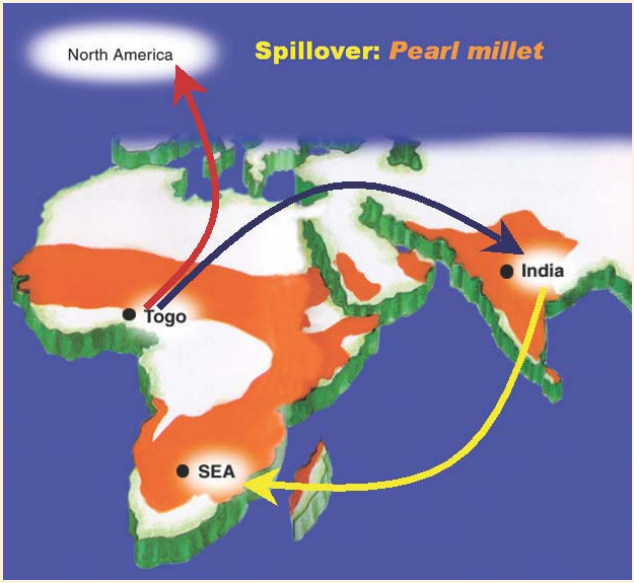


Working with an increasingly broad array of partners, ICRISAT social scientists are narrowing in on the factors that make local communities prosper.

Spillover impacts

Important lessons have been learned through a comprehensive analysis of global spillovers from research on ICRISAT's mandate crops. Is it now clear that the roles of both biophysical and socio-economic conditions must be considered in any realistic determination of the spillovers of agricultural research. Having achieved a better understanding of the constraints that have thus far limited spillover of improved technologies from Asia to Africa, we are now poised to focus on the elimination of these constraints.

Finding out what the farmers think.



Spillover benefits can be spectacular. The above map illustrates a case in point. An ICRISAT millet breeder collected some seeds of a landrace from a farmer's field in Togo. He carried them to India and used them in a trial. Another ICRISAT breeder, visiting from Zimbabwe, liked what he saw. He took the seeds to Namibia, and the rest is history. The Togolese line, modified by ICRISAT interventions, became a best-seller in Namibia. Today, Okashana 1 is the most popular variety in that country.

Prioritizing water in India

ICRISAT social scientists completed a strategic assessment of rural poverty in the semi-arid tropics for a review spearheaded by IFAD. Recognizing the link between SAT agriculture and rural poverty, the scientists identified agricultural strategies to reduce poverty, recommending priority interventions and research directions. The study suggests that given the serious and persistent problems of water scarcity and drought in India, water should be prioritized as an entry point and a catalyst for development activities.

Information repositories for policy advocacy

India's National Centre for Agricultural Economics and Policy (NCAP) and ICRISAT have strengthened their already close collaboration to improve the quality of survey data for more efficient use as policy analysis and advocacy. In the short span of one year, ICRISAT's village-level studies methodology was adopted by NCAP and its 10 cooperating centers for improving data quality and analytical rigor. Both partners significantly benefit from the synthesis generated from a large set of representative villages drawn from many agroclimatic zones of the country, thus establishing information repositories for policy advocacy.

Innovations

Social scientists at ICRISAT have pioneered the use of the innovation systems framework as a way of planning and evaluating agricultural research. The framework initially focuses analytical attention on the patterns of linkage and partnership associated with technical and socio-economic change. It then investigates the institutional context of interventions. A clear impact of this work has been its use as an underpinning concept in the recent CGIAR initiative on Institutional Learning and Change, which seeks to improve the performance and impact of CGIAR science by helping the centers to contribute more effectively to agricultural innovation systems and the development goals to which they lead.

Training

A systematic evaluation of the impact of ICRISAT's learning programs was conducted in 2001. The overall goal was to assess the extent to which our learning program has met its twin objectives:

(a) enhancing the knowledge and skills of the participants, and (b) facilitating the contributions of participants to their national institutions following their training.

Whether training activities are conducted in the classroom (above), or in the field (below), sharing the knowledge gleaned from more than 30 years of research in the semi-arid tropics must continue to be a major priority for ICRISAT.

The results of ICRISAT's training efforts:

- Training at ICRISAT was shown to be demand driven. National program employers sent 46% of the participants, and another 30% were sent through collaborative research projects.
- The overwhelming majority of participants (94%) reported that their training at ICRISAT was necessary for their jobs.
- Participants indicated that their practical skills and subject knowledge had been enhanced through training at ICRISAT.
- Most participants (90%) returned to their jobs immediately after training at ICRISAT. Currently, 56% of them continue in the same job, while 42% have changed jobs.
- For more than half the participants, promotion or improvement in status was attributed to training at ICRISAT. Nearly 37% of the participants later went on to obtain a higher degree (MSc or PhD).
- Ninety-five percent of participants have shared the knowledge and skills with peers, and 55% were involved in training other staff.
- About 80% of the participants are still applying the skills and knowledge gained at ICRISAT, indicating relevance, usefulness and sustainability of learning.
- Nearly 73% participants expressed that their job performance was enhanced by more than double through their exposure to ICRISAT.