Improving the unimprovable

Succeeding with pearl millet

ICRISAT's nomination for the

King Baudouin Award 1996

ICRISAT
International Crops Research Institute for the Semi-Arid Tropics
May 1996

FOOD FROM THOUGHT

A series of narratives on the practical application of research conducted by ICRISAT and its collaborators

Number 3

Improving the unimprovable — succeeding with pearl millet

International Crops Research Institute for the Semi-Arid Tropics

About ICRISAT

The semi-arid tropics (SAT) encompasses parts of 48 developing countries including most of India, parts of southeast Asia, a swathe across sub-Saharan Africa, much of southern and eastern Africa, and parts of Latin America. Many of these countries are among the poorest in the world. Approximately one-sixth of the world's population lives in the SAT, which is typified by unpredictable weather, limited and erratic rainfall, and nutrient-poor soils.

ICRISAT's mandate crops are sorghum, pearl millet, finger millet, chickpea, pigeonpea, and groundnut; these six crops are vital to life for the ever-increasing populations of the semi-arid tropics. ICRISAT's mission is to conduct research which can lead to enhanced sustainable production of these crops and to improved management of the limited natural resources of the SAT. ICRISAT communicates information on technologies as they are developed through workshops, networks, training, library services, and publishing.

ICRISAT was established in 1972. It is one of 16 nonprofit, research and training centers funded through the Consultative Group on International Agricultural Research (CGIAR). The CGIAR is an informal association of approximately 50 public and private sector donors; it is co-sponsored by the Food and Agriculture Organization of the United Nations (FAO), the United Nations Development Programme (UNDP), the United Nations Environment Programme (UNEP), and the World Bank.

ICRISAT

International Crops Research Institute for the Semi-Arid Tropics

Patancheru 502 324, Andhra Pradesh, India

Order code: FTE 003

143–96

Improving the unimprovable — succeeding with pearl millet

This is a story about success. Like all good stories, it describes a struggle to overcome resolute and powerful villains. It includes the ups and downs, the blind alleys, the back-to-the-drawing-board defeats that all storybook heroes ritually encounter. And happily, it also includes the ending we all expect and demand from a good story – the good guy wins!

Specifically, it is the story of ICRISAT's success in breeding new varieties of pearl millet that have been embraced by millions of farmers and consumers who depend on the crop for their sustenance. The difficulty of achieving this success was enormous. The importance of having done so is incalculable.

We are talking about a crop that is virtually *unimprovable* – a crop that grows where not even weeds can survive. A crop that has been improved by farmers and through natural selection for thousands of years. A crop that produces nourishment from the poorest soils in the driest regions in the hottest climates. A crop that grows straight out of sand dunes. A crop that survives sand storms and flash floods.

Asking researchers to come up with ways to improve such a crop is a bit unfair. After all, how can you improve on such outstanding adaptation to intense stress environments? How can you *improve the unimprovable?*

This is a huge challenge – yet this is exactly what ICRISAT's pearl millet scientists have been asked to do. That they have succeeded is the stuff of legends. But since we lack the space for legends, this brochure will have to do.

Our starting point

Pearl millet is the staple food crop of the inhabitants of the world's hottest, driest areas. The people who live there are among the poorest anywhere. They do not cultivate the crop as a matter of choice – where they live nothing else will grow.

Pearl millet farmers have successfully coped with their harsh conditions for centuries. But today, as increasing population trends threaten the sustainablity of their way of life, ancient practices and landraces may not be enough.

Anticipating the needs of the tens of millions of poor people in Africa and Asia who depend on pearl millet, scientists from ICRISAT and their collaborators in various national agricultural research systems (NARS), over

Toughing it out in the Sahel: this pearl millet field in Niger produced grain despite scorching heat and poor soil. Then it was submerged by a flash flood. Despite all this, the farmer will reap a harvest.

the past 23 years, have fostered a focused research program.

Once constraints are identified, research has been tremendously successful in achieving ways to overcome these constraints – development of screening procedures, identification of sources of resistance/tolerance, development and dissemination of improved breeding products, and training.

This team effort has impacted positively on the lives of rural poor, especially in India where nearly half of the world's pearl millet is produced. Further, it has helped stimulate the interest of private enterprise in this "poor man's crop", thus providing a self-sustaining mechanism to ensure that the people of the semi-arid tropics continue to have access to pearl millets that can meet their changing needs.

The bad guys

The most important biotic constraints of pearl millet are diseases. These include two panicle diseases, smut and ergot, and a particularly virulent and difficult systemic disease known as downy mildew.

Major abiotic constraints are drought, heat, and low soil fertility.

Downy mildew in Burkina Faso. Infected heads produce tendrils instead of grain.

The gruesome twosome: ergot and smut

Ergot, caused by *Claviceps fusiformis* and smut, by *Tolyposporium penicillariae*, are the second and third priority diseases after downy mildew. Research on both diseases was initiated in 1976 with the main emphasis on control through host plant resistance. After developing effective field screening techniques, stability of resistance was tested in collaboration with NARS pathologists. Finally, resistant cultivars were bred. Here are some highlights from 20 years of research on these two killer diseases.

- Screening techniques developed at ICRISAT Asia Center (IAC) are presently used worldwide.
- Resistant cultivars bred using popular materials as parents have brought excellent results. For example, the open-pollinated variety Kaufela (ICMV 82132), released in Zambia in 1989, is derived from the Smut Resistant Composite constituted at IAC in 1979.
- Several male-sterile lines have been developed using ergot-resistance sources, and three of these (ICMA 91113, ICMA 91114, ICMA 91115) provide reasonable yield and resistance to both ergot and smut – and even to downy mildew.
- 1488 seed samples of ergot-resistant and 725 of smut-resistant lines have been supplied to scientists in four continents for utilization in resistance breeding and other studies. These are in addition to the seeds supplied to collaborators for multilocational testing in India and Africa.

With the highly successful completion of the objectives of research on panicle diseases, ICRISAT pearl millet scientists shifted their emphasis to Public Enemy Number One: *downy mildew*.

Enter the dragon: downy mildew

The worst scourge of pearl millet, especially of single-cross hybrids, is downy mildew. The disease is caused by a fungus, *Sclerospora graminicola*, a pathogen so highly variable that it can persist in the soil from one season to the next, and can spread rapidly from one susceptible plant to another by means of asexual spores. Downy mildew can reduce yields by more than 40%.

Downy mildew's importance is greatest in Asia, largely due to the widespread use of genetically uniform single-cross hybrid cultivars over the last two decades. About 35% of the pearl millet area in Asia is sown to hybrids. In areas where downy mildew is present, the inherent genetic variability of open-pollinated cultivars reduces losses and minimizes inoculum build-up.

The involvement of pearl millet scientists from all disciplines in the fight against downy mildew is such that it is difficult to discuss the crop without referring to the disease.

Before ICRISAT was founded in 1972, the lion's share of research of the crop was conducted by the Indian Council of Agricultural Research (ICAR) and other Indian organizations. With the availability of cytoplasmic-genic male-sterile lines in the mid-sixties, a succession of hybrids was released. At first the results were very good – yields had never been better. One in particular, HB 3, spread so quickly that by the early seventies it was being sown widely throughout India.

The biggest killer of a staple food crop for millions has been defeated.

And then the bubble burst.

HB 3 had become vulnerable to downy mildew. The disease, which had always been present, but had never approached epidemic proportions, now had a chance to sink its teeth into the genetically uniform plants provided by hybrid seed. The disease devastated the crop. In the end, the hybrid had to be withdrawn from cultivation. Only the farmers' landraces, with their inherent diversity, were able to withstand the onslaught. No high-yielding cultivar could resist downy mildew.

Meanwhile, in Africa, where hybrid cultivars had not been tested or adopted commercially, neither yield increases (the advantage of hybrids), nor downy mildew (the disadvantage) were experienced by farmers.

Following the establishment of ICRISAT and the devastation caused by the downy mildew epidemic on hybrid cultivars, a large number of genetic materials were introduced into India from western and central Africa, the center of origin and primary center of diversity of pearl millet. Now that a Center with an international mandate to improve pearl millet existed, new materials with sources of resistance to downy mildew plus desirable agronomic attributes became more readily available for use in India.

Genetic materials introduced from Africa by ICRISAT significantly increased grain yield and kept downy mildew under control by introducing new sources of resistance. Open-pollinated cultivars like WC-C75 and ICTP 8203 put food in stomachs and smiles on faces. In general, these open-pollinated cultivars remain as resistant to downy mildew today, over 10 years after their first release and widespread cultivation, as they were when first introduced to farmers. Most importantly, the scientists had bought time. By the time the pathogen had found ways to penetrate the resistance of these improved pearl millets, researchers had been able to incorporate resistance from new sources into materials with even better yield and quality.

At the same time, single-cross hybrid cultivars like ICMH 451, ICMH 423, and ICMH 356 were each bred using at least one African parent. Many other materials of Indian origin were crossed with African germplasm. F_3 and F_4 materials were utilized to derive hybrid pollen parents and parents of synthetic varieties. Selections were made using downy mildew screening at ICRISAT Asia Center and other hotspot locations. Examples of such products generated and released are ICMS 7703, ICMV 155, and ICMV 221.

It looked as though downy mildew had met its match. However, the disease was only down and not out. It continued to wreak havoc in the fields of farmers who had no access to the resistant varieties. It is worth noting that although two downy mildew epidemics occurred during the eighties, neither occurred in India on ICRISAT-bred material.

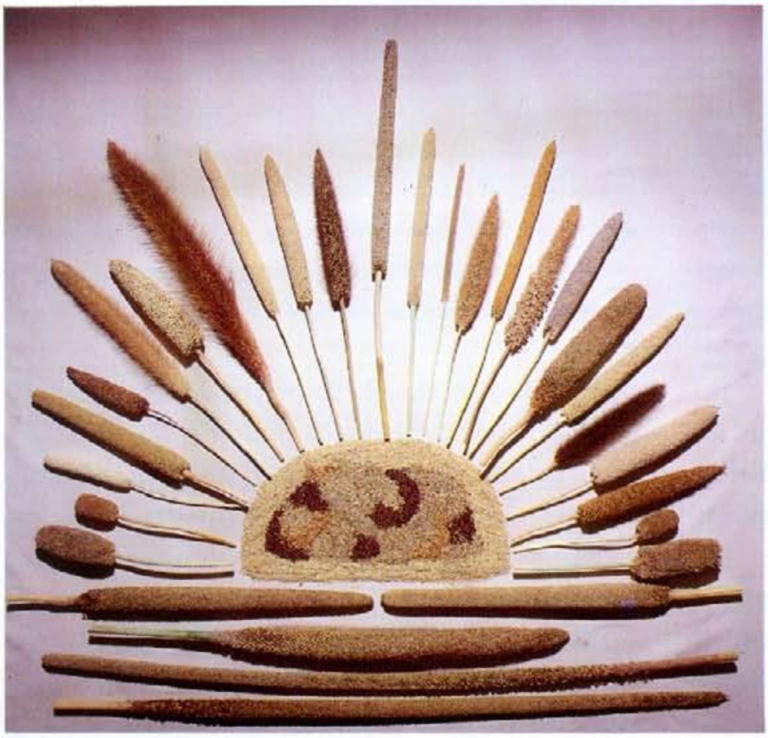
ICRISAT scientists knew that they could not rest on their laurels. Without missing a beat, they went to work to find new ways to overcome their adversary.

Pearl millet – what is it?

Pennisetum glaucum (*L.*) *R.Brown is a cross-pollinated cereal grown for grain, stover, and green fodder on about 27 million hectares, primarily in Asia and Africa. Both open-pollinated and hybrid cultivars are widely grown, although hybrids are largely restricited to India, Australia, and the Americas.*

Pearl millet is the only cereal that reliably provides grain and fodder under dryland conditions on shallow or sandy soils with low fertility and low water holding capacity in hot, dry environments. In the drier areas of Africa and Asia, the crop is the staple food grain. In more favored areas, pearl millet grain is fed to bullocks, milch animals, and poultry. Stover is fed to cattle in areas where other types of feed are not readily available.

Prospering in the semi-arid tropics: a bountiful field of ICMA/B 841.



The biodiversity of pearl millet is spectacular.

Close-up showing pearl millet panicles at flowering to early grain-fill stage. The variety is ICMH 451.

They have been immensely successful.

- Two new classes of resistance have been added to our arsenal: *recovery resistance*, a phenomenon in which both pathogen and host coexist without affecting yield, and *complete resistance*, to which no virulent strain could be identified.
- A method has been developed to select for resistance from the residual variability normally present within the susceptible cultivars. ICMA 841, a male-sterile line now extensively used as a seed parent, for example, has made tremendous impact in farmers' fields.
- Another significant advance was the development of topcross pollinators and topcross hybrids with extremely good yield potential. Because the high level of heterogeneity of the top-cross pollinator broadens the genetic base of the hybrid, the disease can be kept under control for a longer period.
- A systemic fungicide with curative properties has also been identified. This additional tool, known as metalaxyl, can control the disease for short periods when certain resistances become ineffective and alternative resistant cultivars are unavailable.

Genetic geography

But perhaps the most exciting developments have been the recent advances in biotechnological research, particularly molecular mapping.

Until recently, our knowledge of the inheritance of downy mildew resistance was very limited. Resistance was generally thought to be dominant, permitting use of a single resistant parent in breeding resistant hybrids. But resistance of such hybrids has not endured. Further, resistance was often specific to a given pathogen strain. Molecular mapping has demonstrated that:

- many genes contribute to downy mildew resistance,
- these genes are scattered throughout the host genome,
- pathogen-strain specificity is the rule for each of these genes, and
- a large portion of resistance to a given pathogen population can be accounted for by relatively few genes.

Effective mechanisms and strategies for deployment of resistance genes are needed to improve the durability of hybrids. Molecular markers are tools that can be used to implement such strategies. Better knowledge of the geographic distribution of pathogenic variation, and of the inheritance of virulence, could contribute to the identification of more effective strategies, and ultimately to the development of pearl millet hybrids that will better suit the farmers' needs.

Clearly, hybrids with enough heterogeneity for resistance and enough uniformity for agronomic characters will be accepted by both farmers and seed companies. Such hybrids are a possible means of achieving the durable resistance that has previously been available only from open-pollinated cultivars. The first field evaluations of these new hybrids will begin during the 1996 rainy season. If these evaluations are successful, new hybrids with more durable heterogeneous resistance and visual uniformity for agronomic characters, could reach farmers as early as 1998.

The bottom line: although eradication of downy mildew has thus far proved impossible, it can truthfully be said that the biggest killer of the staple food crop of millions of poor people of the semi-arid tropics has effectively been defeated.

Life on the dry side

The title of this narrative begs a question: *If pearl millet is in fact "unimprovable", why continue to invest in improving it?*

Indeed, ICRISAT has found that sometimes it makes more sense to turn its attention from basic research and instead focus on the problems of technology transfer. In cases where suitable pearl millet products are available but not cultivated, our task is to provide farmers with reasons and the means to grow them. In chronically dought-prone areas like southern Africa, for example, switching from maize (which is preferred by consumers) to pearl millet would dramatically enhance farmers' chances of assuring food security.

But even given the crop's ability to grow in dry conditions better than any other food crop, ICRISAT scientists know they must not relax their efforts to fully understand the mechanisms by which pearl millet tolerates drought, so as to incorporate these traits into their breeding products.

ICRISAT's research on drought tolerance in pearl millet has followed a deliberate, planned course. We began by developing a basic understanding of the effects of drought on the crop and the nature of tolerance for different stress patterns. From there we moved on to establishing screening procedures and selection criteria for tolerance.

The research progressed through five specific stages.

- Assessment of effects of timing and severity of stress on pearl millet growth, yield, and yield components.
- Observation of compensatory or adjustment mechanisms in pearl millet subjected to mid-season stress.
- Evaluation and quantification of drought tolerance in pearl millet.
- A simple model of grain yield under terminal stress: the identification of threshing percentage as an indicator of drought tolerance/susceptibility.
- Evaluation of threshing percentage as a selection criterion for terminal drought tolerance.

We are now attempting to develop molecular markers for genes contributing to terminal drought tolerance in pearl millet. If successful, and we expect to be, we will be able for the first time to breed for improved drought tolerance rather than simply evaluating finished breeding products.

Over 50% of ICRISAT's new lines contain germplasm of an African landrace.

An unlikely hero to the rescue

Drought tolerance is particularly important to Sahelian farmers. ICRISAT's work, therefore, has focused on breeding the qualities of the *landraces* – the traditional cultivars of West African farmers – into improved materials. Initially, however, success was limited, mainly due to the narrow genetic variability within these landraces.

This bumper crop of Okashana 1 attracted the attention of Dr Sam Njoma, President of Namibia.

One exception is that of a landrace called Iniadi, which probably originated in Togo. Iniadi fills the bill as far as both abiotic and biotic constraints are concerned. It matures in 70 to 85 days, is well adapted to low soil fertility, resists diseases, and is particularly tolerant of drought. Its yield is variable, ranging from 0.8 to 2.5 t ha^{-1}.

But the special quality of Iniadi is that, unlike most landraces, it can be used as elite germplasm by plant breeders. It shows good combining ability in crosses with a wide range of genetically diverse material. Unusually, it confers earliness together with high yield. Its potential to contribute to the development of early, high-yielding cultivars has been exploited and its use in breeding programs has greatly expanded over the past 15 years. Currently, approximately 50% of the new early and bold-seeded composites and breeding lines developed by ICRISAT contain Iniadi germplasm in their parentage.

One of the major accomplishments of ICRISAT's pearl millet team has been to *use and diffuse* this material globally – and our collaborators have responded in kind. At Kansas State University, USA, for example, Iniadi has become a principal exotic germplasm source because of its earliness even at latitude 39°N. Two of the male-sterile lines resulting from materials supplied to ICRISAT by the University, 843A (ICMA 2) and 842A (ICMA 3), were recommended by the Indian national program for general use as seed parents. This was indeed an enlightened recommendation – today, at least *half* of all hybrids (both numbers and volume) marketed by the private sector in India are produced on these two male-sterile lines.

ICRISAT breeders, working closely with NARS scientists in many countries, have been able to utilize the Iniadi material to produce several significant varieties. In 1980, Iniadi was imported into India from Burkina Faso. It was then grown in a demonstration plot at ICRISAT Asia Center, where it caught the attention of a scientist who selected it for trials in Zimbabwe. From there it was taken to Namibia, where it was enthusiastically embraced by farmers and released as Okashana 1 in 1990. At present it is the most popular variety in that country, the only non-Sahelian nation in Africa where pearl millet is the preferred cereal of consumers.

Iniadi's importance in India is best illustrated by its presence in the genetic makeup of ICTP 8203, the cultivar with the largest hectarage under certified seed production in the country.

In Chad, another product of Iniadi, GB 8735, has achieved significant penetration into farmers' fields. Introduced in 1991 in on-station trials, GB 8735 is expected to be sown on 100 000-125 000 ha in Chad within the next 2 years. It is also widely grown in Mauritania and Benin, where farmers call it *Banadabu*, or "protects the back", because they can harvest a crop in the middle of the season when food stocks are low.

No stone left unturned

In West Africa, low soil fertility, especially as it interacts with drought, is considered by many scientists and farmers to be an even more important problem than drought *per se*. Farmers' best defense against this two-pronged constraint is to sow varieties that both mature early and tolerate stress.

Crop improvement: a collaborative process.

Because fertilizers are not available to the vast majority of Sahelian farmers, an important thrust of pearl millet scientists at the ICRISAT Sahelian Center (ISC) in Niamey, Niger, is to search for ways to enrich the poor soils with biomass provided by plant residues and animal dung.

Collaborative work with the International Centre for Research in Agroforestry (ICRAF) on utilizing residues from trees and shrubs both to enrich the soil and to reduce wind erosion is ongoing. Similarly, joint research with scientists from the International Livestock Research Institute (ILRI) is focused on maximizing the usefulness of animals and animal products to improve productivity. And leaving no stone unturned, ICRISAT also works with the International Fertilizer Development Corporation (IFDC) to assess the severity of the lack of nutrients in Sahelian soils.

To provide the most immediate assistance possible to the farmers of this harshest of farming areas, all three organizations have posted senior scientists at ISC. Spillovers from such collaborative work in the Sahel has had – and will continue to have – important impact on pearl millet cultivation elsewhere.

Long-term strategies

The initial focus in pearl millet breeding was to produce a diverse range of breeding materials and end products with high grain yield and resistance to downy mildew. This focus, which emphasized applied research, is still the case in our work in Africa. Recent years, however, have seen an increasing shift in Asia towards strategic research in the areas of germplasm utilization, breeding methodology, and biotechnology. The ultimate goal is to broaden the genetic base of pearl millet and to address its improvement in the most marginal environments.

Interdisciplinary team effort and partnership with NARS have always characterized ICRISAT's research methodology. Reacting to the new dynamics within the donor community, however, we have strongly shifted the way we conduct our research toward a greater sharing of roles with networks, non-governmental organizations, and farmer groups, as well as the NARS. At the same time, opportunities for collaboration with advanced research institutes in the developed world, especially with regard to gene mapping, are becoming increasingly important. Our long range breeding goals include exploring the potential of pearl millet in such non-traditional environments as South America.

Case study: adoption and impact in Maharashtra

ICRISAT's breeding products are freely available to both the public and the private seed sector. A case study of adoption and impact is given here to illustrate the effectiveness of ICRISAT's collaboration with both public and private research and development programs and the seed sector in India.

ICRISAT social scientists are conducting a series of surveys to determine the extent of adoption and impact of pearl millet breeding research in India. One such survey covered regions in western Maharashtra where 90% of the pearl millet in that state is grown.

To assist adoption and impact of research investments, a three-pronged approach is taken.

- First, seed distribution data are traced from various sources (e.g., ICRISAT, state seed corporations), through the seed sector channels, both private and public, to farmers.
- Second, seed companies are surveyed to elicit information on the value of ICRISAT-based parental lines, seed production, multiplication, and distribution. Information is obtained concerning both favorable traits (to be extracted) and on unfavorable traits (to be restricted).
- Third, on-farm surveys are conducted to determine the extent and rate of adoption.

The expansion of the seed industry in the late eighties and early nineties brought about a significant rise in investment in research. This resulted in a flourishing seed market and availability of improved seeds to farmers in Maharashtra and other pearl millet growing states. The cultivars that dominated during the 1980s were virtually replaced by new varieties and hybrids. The in-

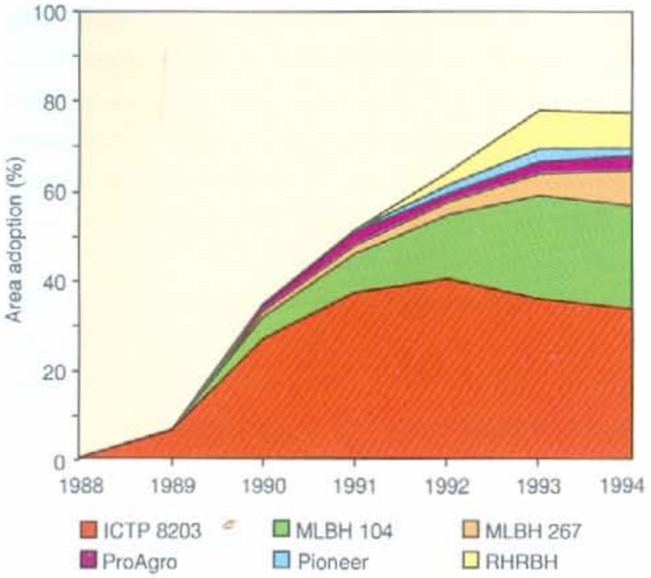


Figure 1. Increasing adoption of pearl millet in Maharashtra.

crease in demand for ICTP 8203, MLBH 104, MLBH 267, RHRBH 8609, and a series of hybrids from ProAgro and Pioneer seed companies from 1989 to 1994 was significant **(Figure 1)**.

Annual returns to Indian pearl millet farmers are double the amount of our annual budget.

The trends clearly show the dominance of ICTP 8203, and the increasing importance of private sector hybrids MLBH 104 and MLBH 267 (Mahendra Hybrid Seed Company), PA 7701 and PA 7501 (ProAgro Seeds) and PO 7602 (Pioneer Seeds).

An aggregate picture **(Figure 2)** highlights two phases showing the changing shares of ICRISAT and the public and private sectors during the period covered by the survey.

This case study was not selected because it particularly favors the argument that ICRISAT is doing its job, but simply because the results are in. Similar studies are under way in several other states. Looking at the country as a whole, our economists have *conservatively* estimated that the annual returns to Indian pearl millet farmers from cultivating varieties of developed by ICRISAT and its partners amount to $54 million. This is about double the annual budget for the whole of ICRISAT, and more than 12 times the cost of our pearl millet research. Now *that's* a payoff!

Farmer participation in breeding

One of ICRISAT's primary goals is to develop innovative techniques to improve the impact of its research on the nutritional and economic well-being of low-income people. Methods that bring farmers and scientists closer together achieve results.

Farmer involvement in the various stages of pearl millet variety development directly addresses the needs of the largest pearl millet growing area in India, the state of Rajasthan, where adoption of modern varieties has thus far been limited.

One of the first activities in any breeding program is to identify goals and to set targets. After experiencing the limitations of working with the farming community using structured questionnaires, we initiated a series of farmer-managed trials aimed at exposing farmers to the widest possible range of improved germplasm in four districts of Rajasthan's major millet-growing region. Using interview techniques adapted from participatory rural ap-

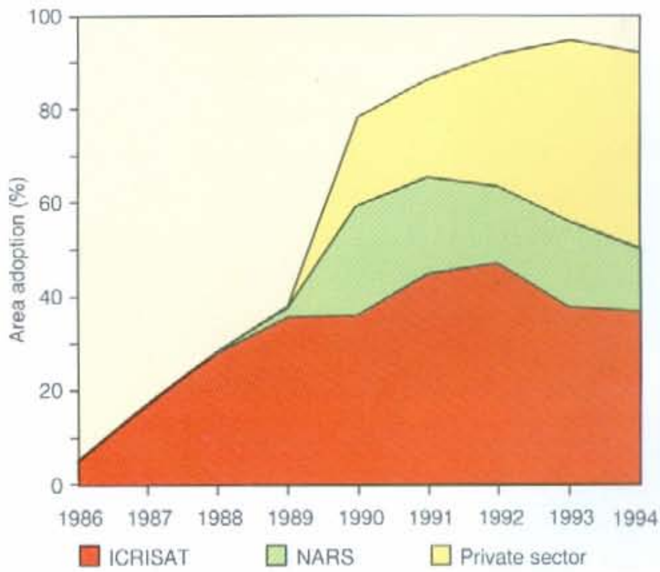


Figure 2. ICRISAT, NARS, and private sector pearl millet adoption in Maharashtra.

Often the best way to get ahead is to get behind... behind the farmers, that is! Here, an NGO worker joins economists from GTZ and ICRISAT in learning how this Rajasthani farmer makes her breeding selections.

praisal methods, we used these trials to understand farmers' preferences for individual traits and specific varieties. And, in an effort to expose farmers to a broader range of new varieties and populations, they were invited to evaluate our on-station trials as well.

We found that Rajasthani farmers usually mention drought as their main production constraint. Discussions on fertility management revealed that farmers perceive a gradual decline in fertility with the increases in cropping intensity over the past 20 years. Discussions with farmers in central Rajasthan about new varieties and their specific traits revealed that their primary concern is the ability of new varieties to produce superior grain yield in a poor year. In the western part of Rajasthan where conditions are the driest, farmers require a specific plant type: high tillering with tillers on aerial nodes, early flowering of the main panicle, thin stems (for good stover), and bristles to provide some protection from birds.

Bringing the farmers into the discussion resulted in unusually quick adoption. When farmers in the study villages in central Rajasthan found that one of the varieties in the trials matched their requirements, seed of this variety was in high demand throughout the district after only two seasons of on-farm trials. Interestingly, the farmers in western Rajasthan did not consider *any* of the varieties used in the on-farm trials as suitable replacements for their landraces. However, many farmers used the new varieties to introduce genetic variation into their own materials. They expressed most interest in varieties with long panicles, large grains, tall plants, and resistance to downy mildew.

In Rajasthan, women play a key role in seed production, selection, and storage – all this in addition to crop management and household chores. Not surprisingly, women's choices were somewhat different from their husbands'. They expressed strong preferences for varieties with high grain yield, large panicles, and lower tillering – plant characteristics that tend to make more grain available during times of severe food shortages.

ICRISAT's insistence on involving the farmers in breeding research is not just a public relations exercise. We take their comments and opinions, and the partnership, very seriously indeed. What we want to avoid is a meaningless circle where we ask farmers what they want, nod in agreement, go away to conduct our breed-

An Indian farmer harvesting a superb crop.

ing activities, and eventually make our recommendations to the authorities. Were we to use this procedure, by the time our products became available to farmers the entire situation may have changed–and the farmers might have died of old age!

In our recently released video *Show me, tell me, explain me...*, the interactive process we utilize in Rajasthan is depicted well. When farmers are encouraged to take the lead in deciding which materials we should use in our breeding program, we get positive and quick results. Perhaps the best outcome is that, after several years of participatory research in Rajasthan, the farmers have grown confident that they are in a better position to control their own destiny.

Summing up

ICRISAT's investment in improvement of pearl millet, the allegedly "unimprovable" crop, is a classic example of multidisciplinary teamwork and research partnership with high scientific merit and real impact on real farming communities in real production environments. We focused on the needs of the poorest of the poor – rural households in the arid margins of the semi-arid tropics – our targets, our stakeholders, and our partners in research.

Success has not come easily. That it has come at all is a tribute to everyone involved. That it is has been achieved so convincingly and in so short a time span is nothing short of remarkable.

Get rich quick – grow pearl millet!

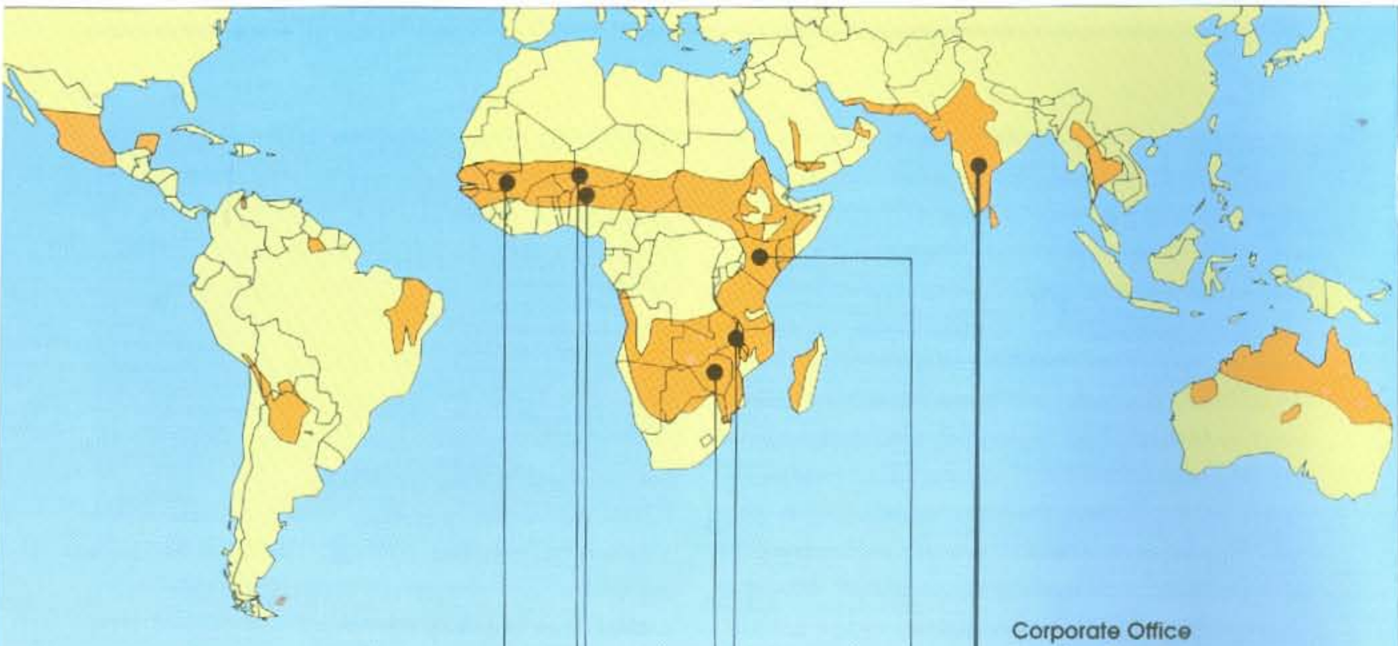
International agricultural research institutes are supposed to focus on poverty, not on wealth. But how can we ignore a man who has suddenly become rich by being on the receiving end of the transfer of ICRISAT technology?

Mr P V Narasimha Reddy lives in the village of Ippalapalli, Andhra Pradesh. Early this year, Mr Reddy agreed to a contract with the Andhra Pradesh State Seed Development Corporation (APSSDC).

In this photograph, Mr Reddy is shown with his plot of 81A and 81B under production for APSSDC. 81A is the male-sterile, 81B its maintainer line. These are the lines used in the multiplication of four released hybrids: ICMH 451, HHB 50, HHB 60. and GHB 181.

From his 1.5-ha plot, Mr Reddy expects to reap 2 tons of 81A and 1 ton of 81B. He anticipates a major return on his investment of about Rs 50 000 in just 90 days – enough, he says, to buy another 1.5 ha of irrigated land!

Mr Reddy's good news extends to the Seed Corporation as well as his neighbors. Because APSSDC sells breeder seed of 81A for Rs 100 per kilogram, and seed of 81B at Rs 47 per kilogram the Corporation will earn an estimated Rs 200 000 (about US$600) from the sale of seed from this single plot. After two further generations of multiplication, each at least 200-fold, the cost of this breeder seed, as well as the price of certified hybrid seed, will become negligible – good news indeed for pearl millet farmers. Best of all, there will be no shortage of seed for hybrids based on this pearl millet A/B pair bred by ICRISAT and its partners!



Corporate Office

Patancheru 502 324
Andhra Pradesh, India

Tel	+91 40 596161
Fax	+91 40 241239
Telex	422203 ICRI IN
E-mail	ICRISAT@CGNET.COM

Western and Central Africa Region

Headquarters
ICRISAT Sahelian Center (ISC)
BP 12404
Niamey, Niger (via Paris)

Tel	+227 722529, 722626
Fax	+227 734329
Telex	5560 ICRISAT NI or 5406 ICRISAT NI
E-mail	ICRISATSC@CGNET.COM

IITA Office, Sabo Bakin Zuwo Road
PMB 3491
Kano, Nigeria

Tel	+234 64 662050
Fax	+234 64 669051, 663492
Telex	77444 KAN BTH NG
E-mail	ICRISAT-W-NIGERIA@CGNET.COM

BP 320
Bamako, Mali

Tel	+223 223375, 227707
Fax	+223 228683
Telex	ICRISAT 2681 MJ
E-mail	ICRISAT-W-MALI@CGNET.COM

Southern and Eastern Africa Region

Headquarters
Matopos Research Station
PO Box 776
Bulawayo, Zimbabwe

Tel	+263 83 8311, 8312, 8313
Fax	+263 83 8253 +263 9 41652
Telex	50581 ICISAD ZW
E-mail	ICRISATZW@CGNET.COM

Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi

Tel	+265 720968, 720906
Fax	+265 741872
E-mail	ICRISAT-MALAWI@CGNET.COM

PO Box 39063
Nairobi, Kenya

Tel	+254 2 741264, 747557
Fax	+254 2 747554
Telex	22795 ICSAT KE
E-mail	ICRISAT-KENYA@CGNET.COM

Asia Region

Headquarters
ICRISAT Asia Center (IAC)
Patancheru 502 324
Andhra Pradesh, India

Tel	+91 40 596161
Fax	+91 40 241239
Telex	422203 ICRI IN
E-mail	ICRISAT@CGNET.COM

ISSN 1017-9933