



Why genetic diversity matters



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Introduction



It is 30 years since IPGRI came into being, as the International Board for Plant Genetic Resources, under the protective wing of the Food and Agriculture Organization of the United Nations. For all that time, regardless of the focus of its work, IPGRI has taken it as axiomatic that agricultural biodiversity is a good thing.

In the beginning, it was the vanishing diversity of locally adapted varieties, fundamentally useful to plant breeders in their efforts to improve crops, that IPGRI helped to collect and protect in *ex situ* genebanks. IPGRI was then among the first to recognize the crucial role that biodiversity, including forest biodiversity, plays in the farming systems of developed and developing countries. By enhancing the value of biodiversity, IPGRI and its partners helped people to conserve and use diversity *in situ* on farms.

Unfortunately, the importance of agricultural biodiversity is still not widely understood, even among fellow scientists. That is why IPGRI was glad to have the opportunity to lead a symposium on 'Why Genetic Diversity Matters' at the 2003 Annual Meeting of the Crop Science Society of America. Six speakers from developed and developing countries and the public and private sectors discussed the role of genetic diversity in agriculture today and its value for the agriculture of tomorrow.

Much of what was said was positive and optimistic, although naturally difficulties remain. This booklet gives readers a flavour of the discussions, positive and negative, and makes the case that diversity does indeed matter, now and for the future.

As IPGRI moves forward into a new phase we believe that agricultural diversity can make a fundamental contribution to sustainable development. We will have to make full use of it if we are to stand any chance of meeting the key millennium development goals of halving poverty and hunger and protecting the environment in a sustainable manner by the year 2015.



Why genetic diversity matters

Diversity is the foundation on which improvements are built. It is the source of all the traits that enable crops to grow efficiently and to provide people with the products they need.



In the UK every autumn thousands of people enjoy Apple Day, a festival celebrating hundreds of varieties of apples. In Nepal some subsistence-

farming households grow as

many as 22 different kinds of rice. This is no mere sentimental fondness for lost foods. Whether for cultural reasons or the more basic need to ensure a secure food supply, most of us appreciate that we benefit from plant diversity. But few are as close to an instinctive understanding of its real value as the world's farmers.

Australian farmers are probably the last people in the world you could accuse of being sentimental. So they must have had a pretty good reason to be among the first to pledge, through their Grains Council, US\$5 million to a new international trust that aims to secure the future of the world's most important collections of old varieties, landraces and wild relatives

Innovative farmers were breeding from their best landraces long before Mendel discovered the laws of genetics.

of crop plants. From Nepal to Nebraska, sustainable agriculture depends on plant diversity.

Farmers instinctively go for new varieties that will improve their yields, says Stephen Smith, coordinator of germplasm security and a

research fellow at the US seed company Pioneer Hi-Bred. Smith, a member of IPGRI's board, said "in the USA, innovative maize farmers were conserving, selecting and even breeding from their best landraces

long before Mendel discovered the laws of genetics.” Without the constant improvements made by plant breeding, he added, agriculture in the USA would by now be unsustainable. “Even with 1990s husbandry techniques and modern fertilizers and crop protection, you would need an extra land area the size of Texas to grow today’s production of maize, wheat, cotton, sorghum and soya bean. And the best land is already in cultivation—finding that extra 64 million hectares would mean wholesale loss of natural habitats.”

Farmers in less developed countries have just the same instincts for selecting and using the best-performing crop strains. Indeed, they may be more attuned than their

counterparts in the industrialized world, who these days rely on big seed companies to give them the plant characteristics they need.

“Genetic resources are one of the few resources available to poor farmers in developing countries,” says Bhuwon Sthapit, a plant breeder who now works for IPGRI in Nepal, collaborating with local non-governmental organizations to promote community-based conservation. “With a wide diversity of landraces and cultivars farmers can spread their risks, especially where the land or climate are variable.”

Sthapit says that in a study in

Begnas village in Nepal, where the land ranges from 600 to 1200 m in altitude, around 1000 households maintain some 69 rice varieties, just six of them modern cultivars. “The landraces as a group contain huge variation,” says Sthapit. “You can’t simply put them in a single group. Some of them are competitive with modern varieties, better in certain situations. The decision on which varieties to use depends on the environment at the planting site and the yield and eating quality of the variety,” he said. “Some of the



varieties are grown only in very specific places—often where nothing else will grow well.” For example, some are adapted to waterlogged marshy soil while others are more widely grown. But no single landrace accounted for more than 17% of the total rice area.

Not surprisingly, the study found that varieties or landraces that are likely to give the highest yields or generate the most income, such as Basmati and Jetho Budho, were grown by most households; those that were valued more for their cultural associations or good flavour were still highly prized and grown by most people but on a smaller area.

“There are many values people place on their rice varieties, not just yield,” says Sthapit. “Some



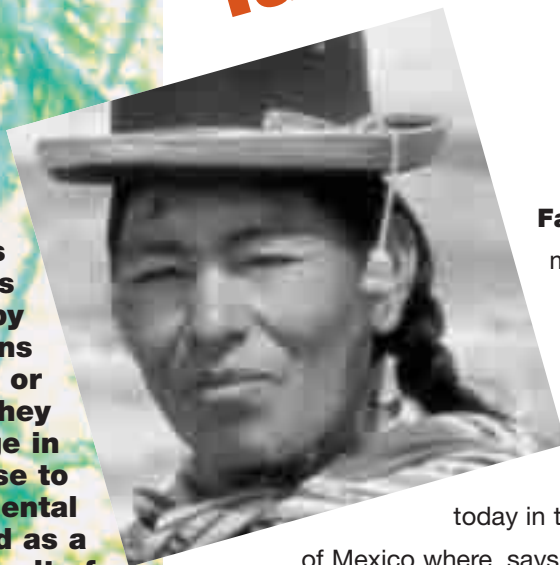
varieties, such as Sathi, have religious or cultural significance. Anadi is used for backache, while Bayarni is considered especially nutritious for pregnant women. Biramful is particularly aromatic, soft and tasty. All these things are just as important in a family’s decisions about what to grow.”





Dynamic landraces

Most varieties that farmers use are by no means fixed or static. They change in response to environmental shifts and as a result of conscious selection by farmers.



Farmers constantly modify and select the best strains in a dynamic, ever-evolving process.

That dynamic is being played out today in the central highlands

of Mexico where, says Smith, the introduction of modern commercial varieties of maize is changing the way farmers use their landraces: “Farmers are making hybrids between landraces and modern cultivars as well as creating new landraces by crossing older ones. Landraces are not static, on a shelf. They are used and changed by farmers.”

Essential technical knowledge about the diversity of local landraces is as important to conserve as the varieties themselves.

Sthapit agrees with the need to improve the choice of varieties available to farmers in less-developed countries but says the role of existing landraces, and of the farmers themselves, is also something that’s often overlooked. “In every farming

society, some farmers are particularly interested in seeking out and working with new varieties, and sharing their knowledge with their neighbours,” he says. “We call them ‘nodal farmers’ and they can play a central role in local development and take-up of new varieties.” They also have an essential technical knowledge about the diversity of local landraces that’s as important to conserve as the varieties themselves.

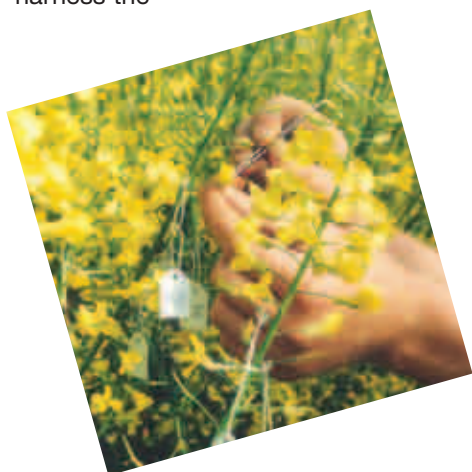
One project in Nepal improved the quality of the variety called Jetho Budho by working with nodal farmers to select the six best strains from samples

submitted by more than 350 households. The people who had submitted these six were then asked to produce seed to share with other communities. In another project the rice landrace Mansara—of poor eating quality but hardy and a reliable performer on marginal lands—was crossed with the modern cultivar best suited to Nepalese hill-farming conditions. Again local farmers helped to make the final selections from the resulting seedlings.

Rodomiرو Ortiz, Director of Research for Development at the International Institute of Tropical Agriculture (IITA) in Nigeria, says there are many examples of how a modern understanding of genetics, plant breeding systems and biotechnology offers more opportunities than ever before to harness the

most useful qualities of landraces and the wild relatives of crops in plant breeding programmes.

“For example,” he says, “elite breeding lines of peanuts with multiple disease and insect resistance have been developed in breeding programmes involving wild species—because breeders have been able to use hormone treatments and embryo rescue to overcome incompatibilities between wild peanuts and modern cultivars caused by different numbers of chromosome sets.” This is complex work, and yet “one cultivar is already in production in Mauritius as a result.”





Breeding goals

The public sector has to take up the challenge of breeding to meet the needs of farmers in developing countries. That means asking what they want and helping them to find the diversity that will satisfy those wants.



Ortiz has been working with IITA's partners to address the well-publicized problem of disease susceptibility in the world's banana crop.

"Much of the publicity has concerned the export banana industry," he says. "But 90% of banana production is actually for local consumption." The average Nigerian, for example, eats 43 kg of bananas a year. In Uganda it is six times as much. The diversity of bananas used locally is much higher than in the export crop, and includes highland dessert bananas, plantains and cooking types. But only with the development of advanced breeding techniques has it become possible to use the diversity in landraces such as *Cardaba gaddat*, or wild species such as *Musa balbisiana*, to breed improved bananas.

Banana breeding is in the hands of publicly funded bodies such as IPGRI's International Network for the Improvement of Banana and Plantain (INIBAP) and IITA. Commercial vegetable breeder Orlando de Ponti, Managing Director of Nunza B.V. in the Netherlands, says it is equally important for private breeders to have access to genetic diversity beyond that present in current commercial cultivars. "In commercial breeding, most crosses involve the best competitors' strains," he says. "Although that results in an average yield improvement of about 1% a year it is still important to go back to wild relatives or landraces now and then to widen the genetic variation you are working with."

Smith agrees, but asks: "Who's conserving the landraces and the wild diversity once farmers move away from using them?"





Secure genebanks

Genebanks were launched in an atmosphere of crisis, to protect the world's crop diversity. Now they are in need of protection themselves if they are to continue to be a safe store of raw material.

The irony, according to Stephen Smith, is that “society has invested billions of dollars in researching genetics and developing biotechnology but

has been ignoring the fact that biodiversity is wasting away. There's no point having the techniques if you don't have the raw materials—the genetic diversity—to use them on. It's as if we'd learned a new language, only to discover that all the books we want to enjoy are crumbling to dust.” Plant diversity under threat on farms or in the wild can be conserved as collections of seeds, tissue cultures or even living plants in genebanks. But how much security do the world's 1400 genebanks provide? And how handy are they for would-be users of the diversity they contain?

Breeders aren't using genebanks as much as they did two decades ago. In the late 1980s, genebanks distributed some 60 000 samples every year to breeders and other plant scientists. Now it's more like 10 000.

If genebanks don't have information about the characteristics of the plants they contain they are of little value.

One reason is the rise of intellectual property rights and sovereignty over genetic resources. But another is that many genebanks are poorly managed and suffering from a lack of resources.

“An early part of the breeding process is to identify and obtain useful characteristics,” Ortiz says.

“Genebanks should be an important source of raw material for breeders but if they don't have information

about the characteristics of the plants they contain they are of little value.”

Ortiz calls providing this information ‘germplasm enhancement’ and without it collections just won’t get used. For example, 17% of the world’s stored samples of sorghum have never been used in a breeding programme and a further 15% have been used only five times or fewer in the past 25 years.

De Ponti says: “Among commercial breeders, we generally feel that genebanks are important. But when a survey asked about the actual use of genebank material it turned out that fewer than 5% of the crosses made each year involve such material.”

Helping genebanks to survive and become more useful is one goal of the Global Crop Diversity Trust. Geoff Hawtin, Interim Executive Secretary of the Trust, says that some 400 genebanks in 75 countries are capable of storing material medium to long term and of these 35 meet internationally agreed standards. “But,” he says, “many genebanks are in a parlous state, unable to look after their collections

properly. The situation is worst of all in developing countries.

“Between 1995 and 2000, 7% lost portions of their collections. Sixty-five percent saw their budgets either remaining static or declining. Worst of all, of the six million accessions, up to a million are in urgent need of propagating or regenerating.”

Hawtin says the Trust was set up to ensure the long-term conservation of plant genetic resources for food and agriculture. “We need to raise an initial \$260m endowment fund to support the long-term maintenance of some of the most important genebanks and coordinate their activities; duplication can waste resources.” So far the Trust has been promised US\$40m from national governments of countries such as Australia, Canada, Colombia, Egypt, Switzerland and the USA; and private companies such as Syngenta and DuPont, parent company of Pioneer Hi-Bred—not to mention those Australian farmers.





Farmer breeders

Many farmers constantly use diversity to improve their existing varieties, consciously bringing in new material or simply by selecting from their harvests. Genebanks and researchers are working with them.



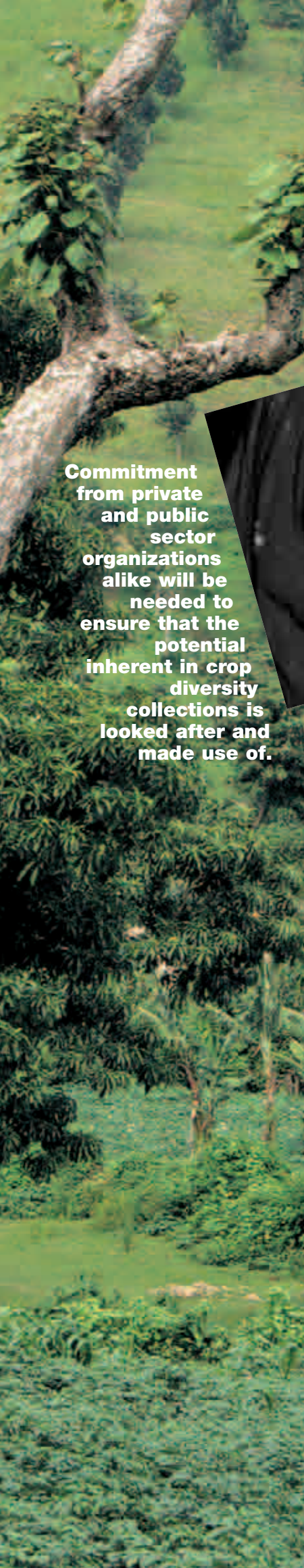
Of course genebanks are not the only repository of crop plant diversity. Sthapit points out that, in developing countries at least, nodal farmers and the seed-exchange networks that develop around their communities can act as an

informal community seedbank, in which people maintain and select varieties and exchange them at seed fairs. In these situations perhaps only those landraces grown on small areas by a very few households need conservation off the farm in a genebank.

A new approach to helping farmers make use of diversity is participatory plant breeding, in which farmers, breeders and other experts come together to develop the kinds of variety that directly meet the farmers' needs, often with injections of additional diversity from genebanks. The rice farmers of Nepal are doing exactly this kind of decentralized breeding, using their local landraces and modern varieties as parents. That helps to conserve local diversity on the farms. But as Smith points out, even in developing countries the situation is not static and farmers are not deliberately conserving landraces. The only varieties that they support are those that meet the farmers' current needs. "Ancient patterns of diversity are changing in developing countries," he says. "Only 3% of the spring bread wheat area in the developing world is now sown to landraces" although much of the rest makes use of landraces in its parentage.

"Society has to step in to conserve the crop diversity farmers can't conserve," Smith says. "The private sector needs to contribute to conservation and should lobby for wider support."





Conservation for future use

Commitment from private and public sector organizations alike will be needed to ensure that the potential inherent in crop diversity collections is looked after and made use of.



Smith says conservation will fail if it is not integrated with development needs—and breeders need access to genetic resources. “But the

[low] commercial rates of return on conserving genetic resources mean it has to be through public or foundation funding, to which the private sector can contribute. The returns are not there for private sector funding.” He believes that support from breeding companies is essential to leverage public funding for conservation. DuPont has promised the Global Crop Diversity Trust US\$1m over the next four years. “We have a duty of stewardship as well as a need as a society to protect our options for the future,” Smith says.

De Ponti says there are practical ways, too, in which private sector breeders can support publicly funded genebanks. “Even the smaller breeding companies can help by growing-out genebank accessions to rejuvenate them.” de Ponti’s company already does this for some genebanks in return for an agreement to be able to use interesting varieties in its breeding programmes.

“But it is a sensitive issue,” de Ponti added. “Breeders are often accused of biopiracy, grabbing landraces and wild genes, making a new variety in six months and a huge profit.” The result, he says, of a few highly publicized cases that most reputable breeders disown. “Now many genebanks refuse help but have become unable to take care of their collections. Material is dying. If you don’t continually regenerate samples these genebanks will simply become mausoleums.”

Ironically international laws and agreements intended to clarify the situation have not always worked.



International agreements

The climate of world opinion about who owns crop genetic resources has shifted in recent years, making new approaches to these thorny issues necessary and desirable.



The fall-off in breeders' use of samples from genebanks during the 1990s was only partly because genebanks were strapped for resources. "It

followed the introduction of the

Convention on Biodiversity," Ortiz explained.

The CBD, which deals with access and benefit sharing, made it harder for breeders to get agreements to use plant genetic resources. And projects to collect more examples of landraces and crop wild relatives for genebanks also ground to a halt.

Smith and de Ponti argue that private sector breeders need strong intellectual property rights to make it worth taking the commercial risks of using untried genetic resources in their breeding programmes. Although society, in the end, reaps some benefit from its investment in conserving genes, breeders should be rewarded for taking the commercial gamble of trying to turn them into useful crops, they argue.

In many places there are no mechanisms to say who is the owner of a local landrace.

But Sthapit says that while international agreements such as the CBD have addressed the theory of benefit sharing, many practicalities remain unresolved. "For example, in

many places there are no mechanisms to say who is the owner of a landrace," he says. "Local people are often happy to regard landraces as god given and to share them with other members of their community. But if a breeding company finds something that it can use in a successful cultivar, how do you get benefits back

to the farmers who have maintained it?”

Jaime Estrella, who coordinates IPGRI's Genetic Resources Policy Initiative, points out: “Most of the diversity farmers are interested in is in plant species that have become spread about the world since the dawn of civilization. It is impossible, and probably not desirable, to trace which country should be the owner of particular agricultural species. You need a multilateral approach.”

He says the lack of trust de Ponti identifies between conservation and business interests is partly down to the ways in which international conservation treaties interact with the World Trade Organization's trade rules,

particularly its intellectual property agreement (TRIPS). “They both affect conservation and use of biodiversity but they are not always in harmony,” he says. “National or regional interests are not addressed by international agreements. There is competition for the control of genetic resources and this can hamper their effective conservation as well as their use.”





Conflict or collaboration

The world has to work out ways to make full use of plant diversity while at the same time ensuring that the farmers who create and manage those resources share in the benefits.



Jaime Estrella points out that the CBD and TRIPS could be interpreted as being in conflict, with the CBD encouraging protection of traditional knowledge,

innovations and practices, while TRIPS forces the use of patents or plant variety rights to protect commercial interests. "Conservation and privatization then appear as contradictory goals with extreme intellectual property regimes leading to uniformity and introduction of new varieties that unintentionally displace farmers' varieties."

But TRIPS can also be interpreted as supporting the CBD, he says. "The private sector must be able to protect its results. But protection can also trigger benefit sharing. Protection laws do not have to stop communities using their indigenous products and processes. If plant breeding is enhanced by effective intellectual property legislation, the result should be

more—and more useful—crop diversity for farmers."

Researchers are not getting enough new genes so farmers are not getting new varieties.

Estrella says the 2001 International Treaty on Plant Genetic Resources for Food and Agriculture, already ratified by 34 countries, will

help resolve the conflicting interpretations of trade and conservation legislation and, most importantly, help to get genebanks and breeding networks working again. The need is urgent, Estrella says. "There used to be three to five exchanges a day coming out of genebanks, that's now almost stopped. Researchers

are not getting enough new genes so farmers are not getting new varieties. Genebanks are becoming just gene museums.”

Agreements made under the Treaty—which covers practically all the plant species that humans depend on for their food supply—will make genetic resources available for direct use by farmers, for conservation research, for training and for breeding. If a breeder develops a commercial variety or some commercial product as a result, and if the product is protected by intellectual property rights such that it cannot be used in further research, then a royalty becomes payable. The royalties will build into a fund that will be used to help small farmers in developing countries, not just with direct income but also through

information exchange and practical research programmes.

Hawtin says it’s the middle-ranking bureaucrats who still need convincing of the importance of conserving agricultural biodiversity, whether in genebanks or growing on farms.

“Too many people still think modern agriculture is the way to improve everything, they want to get rid of the landraces because [they think] that’s what is holding development back. But the developing world will depend on its own crops and biodiversity for many years to come. There are too many different habitats and

cultural needs for commerce to address.”

And we’ll all continue to need the insurance policy of genetic diversity to meet the challenges of the changing world ahead.

“Why does genetic diversity matter?” asks Smith. “How humans use diversity in farming determines our food, our health and our economic well-being and that in turn determines our political security—there’s nothing more important right now.”



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Emile Frison
Director General, March 2004

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Geoffrey Hawtin, Interim Executive Secretary of the Global Crop Diversity Trust, was Director General of IPGRI from 1991 to 2003. He has worked at Makerere University in Uganda and was Deputy Director General of ICARDA, Syria.



Orlando de Ponti spent 20 years in public research in plant breeding and plant protection, and since 1991 has been managing director for R&D of Nunza B.V., an international vegetable seed company based in the Netherlands.

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Stephen Smith is a Research Fellow at Pioneer Hi-Bred International, Inc. and a Board member of IPGRI. His research interests include the characterization and measurement of genetic diversity using molecular markers.



